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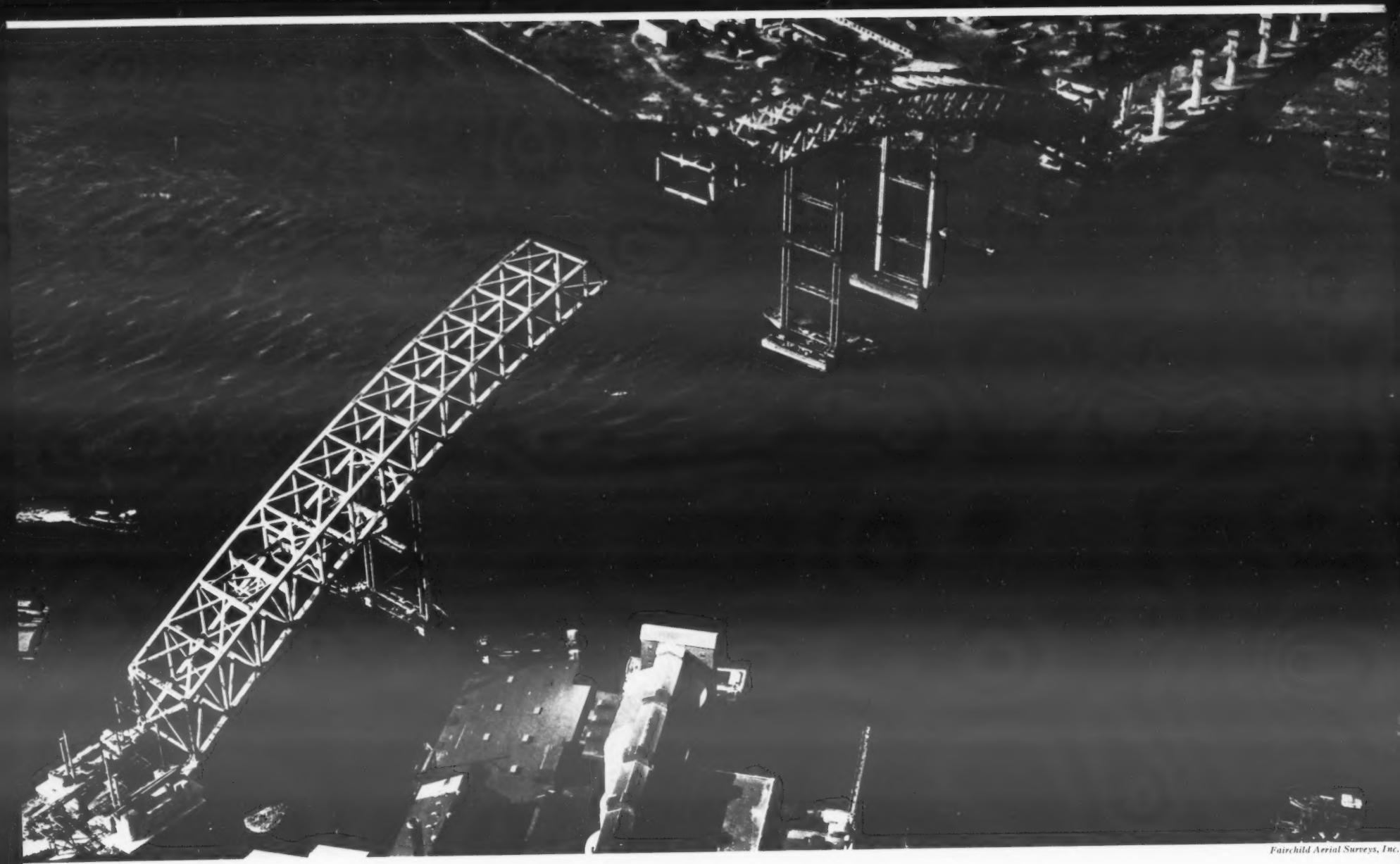

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THE KILL VAN KULL BRIDGE

ERECTING THE WORLD'S LONGEST STEEL ARCH BY MEANS OF
COMBINED CANTILEVER AND TEMPORARY FALSEWORK METHODS

THE TECHNOLOGY
REVIEW
VOLUME 33 JULY, 1931 NUMBER 9

BROBDINGNAGIAN BRIDGES

A Great Engineer Discusses (1) Spectacular Achievements of Modern Bridge Builders (2) Is a Span Two Miles Long Structurally Feasible? (3) Making Bridges Beautiful As Well As Strong

BY OTHMAR H. AMMANN

See page 434

A HUNDRED years ago it was predicted that the famous bridge across the Menai Straits in England, with a span of 570 feet, would forever constitute a world wonder. Only 50 years later that maximum length of span was more than doubled and the suspended mass increased tenfold in the Brooklyn Bridge across the East River in New York. And if we compare Brooklyn Bridge, which 50 years ago was by far the most outstanding engineering work of its kind, with the Hudson River Bridge in New York now nearing completion, we find that the span length in the last 50 years has again been more than doubled, the traffic capacity multiplied at least four times, and the total mass suspended over the river more than eight times.

COMPACTING THE WIRE CABLES OF THE HUDSON RIVER (GEORGE WASHINGTON) BRIDGE

It is also of interest to note that in spite of this enormous increase in the mass and quantity of material in the Hudson River Bridge, the time of construction will be less than one-half that consumed by the Brooklyn Bridge, and that the total cost, in proper consideration of the depreciation of the purchase value of money, will be less than twice that consumed by the much smaller Brooklyn Bridge. These results have, of course, been made possible only by the far-reaching developments in other technical lines, such as mechanical and electrical engineering, and metallurgy, as well as in the field of theory and experiment.

From the engineering or technical point of view, progress in bridge construction manifests itself in improved types and forms of construction and details, in better and stronger materials, in more accurate and cheaper shop-work, and in more expeditious and safer erection, all of which are essential for the construction of larger bridges. It is principally along these lines that I desire to illustrate progress made in recent years.

Types of Bridges

The selection of the type or form of bridge to be used for any particular crossing is, from the engineering point of view, one of the most important factors in the construction of large bridges, and is a question which has often led to animated discussions and differences of opinions in the profession. It is a question which depends upon many different factors and not in the least upon the personal conceptions of the designer.

CANTILEVER ERECTION OF HELL GATE ARCH BY TEMPORARY BACKSTAYS

At the beginning of this century and up to as late as the World War, two types of bridges appeared to be particularly favored, although they are generally the least satisfactory from the æsthetic point of view: the cantilever bridge for the longer spans and the simple span truss type for the lesser span lengths of up to 700 feet. The most outstanding example of the former type is the Quebec Bridge across the St. Lawrence River with a main span of 1,800 feet, which until recently has been the longest span in existence. The longest simple span is that of the bridge across the Mississippi at Metropolis with a length of 720 feet (see page 443).

Many bridges of the cantilever type have been built across the Ohio, Mississippi, and other wide streams. To the most recent and typical examples belong the two bridges built by The Port of New York Authority across the Arthur Kill in New York. The type is particularly suitable where foundation conditions make other types expensive or subject to the effect of possible settlements. But its merits, particularly the alleged advantage of its being statically determinate, have been overrated.

For a long period there existed a very general prejudice against the so-called continuous truss, so much so that, in spite of its economic advantages, it was practically excluded from consideration in favor of the simple truss or the cantilever. Its application in 1916 in the bridge across the Ohio at Sciotoville with two spans of 775 feet each marked a revival of that meritorious type and it has since been employed in quite a number of bridges (see page 442).

Less frequently, and only under favorable circumstances, such as the presence of rocky abutments to resist its thrust, has the arch type been used. Until the present the famous Hell Gate Bridge, completed in 1917, across the East River in New York with a span of nearly 1,000 feet has been the most outstanding example, but it is now being outranked by two bridges, both now nearing completion; namely that across the entrance to Sydney Harbor in Australia with a span of 1,650 feet, and that across the Kill van Kull in New York with a span of 1,675 feet.

The suspension bridge is the type eminently suited for long spans and is now recognized as the only one to be considered for very long spans. The true nature of this naturally graceful type has long been misunderstood and it is only very recently that it has begun to regain the prominent position which it occupied in the early part of the Nineteenth Century. A large number of bridges of this type, particularly for highway and combined highway and rapid transit rail traffic, have been built in the last 10 or 15 years, even with moderate spans, and its greatest length of span has been continuously leaping to new records.

The Manhattan Bridge in New York with a span of 1,470 feet was the most outstanding modern suspension bridge only 10 years ago. Since then there followed in rapid succession the Bear Mountain Bridge across the Hudson with a 1,630-foot span, the Delaware River Bridge in Philadelphia with 1,750 feet, the Detroit River Bridge with 1,800 feet and now the Hudson River Bridge nearing completion with 3,500 feet. And a start has been made on the Golden Gate Bridge in San Francisco with a span of 4,200 feet.

A factor which, I believe, has very materially contributed to the revival of the suspension bridge, is the changed conception regarding the proportioning of the so-called stiffening system of this type. As a result of the insufficient rigidity of many of the early light and short suspension bridges it became a general practice here and abroad to proportion suspension systems as rigid systems, such as the truss or the upright arch. This theory leads to enormous waste of material in long-span suspension bridges, more particularly those bridges carrying highway or mixed highway and rail traffic, because it does not take into consideration the stiffening effect of the large suspended mass, compared to the relatively much smaller load units which cause the span to sag or

SCIOTOVILLE BRIDGE OVER THE OHIO RIVER. LONG SPAN CONTINUOUS TRUSS (2 SPANS OF 725 FEET)

720-FOOT SPAN OF THE METROPOLIS BRIDGE OVER THE OHIO

oscillate. Conspicuous stiffening systems also give an unsightly, clumsy appearance to such bridges and destroy the gracefulness of the cables hanging in their natural catenary.

Today the justification of a flexible, more economical, and more graceful stiffening system in long and heavy suspension bridges is generally recognized. Studies made in connection with the Hudson River Bridge indicated that such a long span of 3,500 feet, with comparatively short side spans, designed to carry vehicular and rapid transit traffic, required practically no stiffening of the freely suspended cables. Accordingly, the bridge was designed and is being built without any stiffening whatsoever in its initial stage, in which only the upper deck for highway traffic will be in place. When the lower deck for rapid transit rail traffic is added, it will have comparatively flexible, very light stiffening trusses between the two decks.

When it is considered that in such a long span every pound of steel unnecessarily applied for stiffening is merely ballast, and that this pound of useless material requires the use of another pound of material in the cables, towers and anchorages it may be realized that such wasteful proportioning involves millions of dollars.

Quality of Materials

AN IMPORTANT phase in the development of long span bridge building is the improvement of the materials, more particularly the introduction of so-called high strength alloy steels, for high strength material does not only effect a reduction in the dead weight which in large bridges may mean a saving of millions of dollars, but it makes possible certain structural members and connections of large proportions which would be impracticable with ordinary steel. For riveted members and connections a medium hard structural steel of from 55,000 to 70,000 pounds per square inch is still generally used for ordinary bridges.

About 25 years ago nickel steel, which has a strength of about 50% greater than the ordinary steel, was introduced and found increasing application in large bridges, as for instance in the Quebec Cantilever Bridge, in the stiffening trusses of the Manhattan Bridge, and also in a number of long simple span trusses.

During and after the World War silicon steel entered the field in sharp competition with nickel steel. Its strength is about 40% greater than ordinary steel or about 7% less than nickel steel, but it can be manufactured at a materially smaller cost than the latter. In fact, its cost has now been so reduced that it can be used economically even in bridges of medium size in place of ordinary steel. The towers and floor structure of the Hudson River Bridge are built almost entirely of silicon steel.

In the case of the Kill van Kull arch with its exceptional span of 1,675 feet, manganese steel was introduced for the heavy main arch ribs. Its strength is equivalent to that of nickel steel, but its price was slightly less. In this same bridge there was also used for the first time manganese steel for the rivets with a strength of about 60% in excess of that of ordinary steel rivets.

For suspension bridges in particular the marked improvement in quality of wire steel was of importance. Since the construction of the Brooklyn Bridge in which steel wire of 160,000 pounds per square inch strength was used for the first time in place of the earlier wrought iron wire, the strength of wire successively stepped up to a new record in almost each new large bridge until it has now reached a strength of nearly 240,000 pounds per square inch in the cables of the Hudson River Bridge.

METHOD OF ERECTING CANTILEVER BRIDGE. OUTERBRIDGE CROSSING AT NEW YORK

The question is frequently asked what would be the maximum practicable length of span. The answer to this depends essentially upon the quality of steel wire. With the quality now available it would be structurally feasible to build suspension spans of up to about 10,000 feet in length. Such a span, of course, would be extremely costly and probably nowhere justified financially.

Shop Fabrication

IN THE fabrication of structural steel members in the shops important improvements have been made in the past 20 years which were essential for the building of large bridges. Inaccuracies in the fabrication of steel members were largely responsible for the failure of the Quebec Bridge in 1907. Since then more accurate methods and powerful machines have been introduced so that in the present day large bridges a remarkable degree of accuracy is being obtained. Thus, for instance, the towers of the Hudson River Bridge were erected with an accuracy of three-sixteenths inch in a height of 600 feet, and the 1,675-foot arch span of the Kill van Kull Bridge was closed with a difference of one-half inch from the theoretical length.

Today individual members of greater size and weight are being completely assembled in the shops. While 30 years ago members of 25 to 30 tons weight were exceptional, the weight attained today is not infrequently 80 to 100 tons and in a few cases 150 tons. The accurate fitting together of connecting members is also being given great care today. In some cases whole trusses, or large portions thereof, have been completely assembled at the shops.

Field Erection

WHEN we compare the present day erection of large bridges with that of 20 or 30 years ago, we notice two striking improvements; the speed with which enormous masses of steel for large bridges as well as buildings are being assembled in the field, and the avoidance of cumbersome falsework and erection equipment. The structures often appear during construction as if they were erecting themselves, and this is literally the fact to the extent that frequently members of the final structure proper are being used to lift or temporarily support other members or parts of the structure. Where falsework is unavoidable, it is almost invariably built of steel members which are often members of the permanent structure.

Erection of bridges by the so-called cantilever method with or without partial use of falsework, is very common today, not only for cantilever bridges, but for simple and continuous trusses and for arches. The absence of falsework of any kind is particularly striking in the erection of the towers of suspension bridges. A simple frame carrying the erection derricks and lifting itself up along the completed portion of the tower is the only temporary structure.

The erection of the wire cables in America is accomplished by the old and well-tried method of "aerial spinning," in which the individual wires are pulled from one anchorage to the other over the towers. Then, packed in bundles or strands, the wires are lifted from temporary into final position in the cable and finally the cable is compacted into cylindrical form and wrapped with a layer of finer wire (see page 441). While the principle of this method is an old one, having been used already 50 years ago in the Brooklyn Bridge, the machinery and equipment necessary for the spinning have undergone radical improvements which have resulted in greater accuracy and speed of erection.

Theory and Research

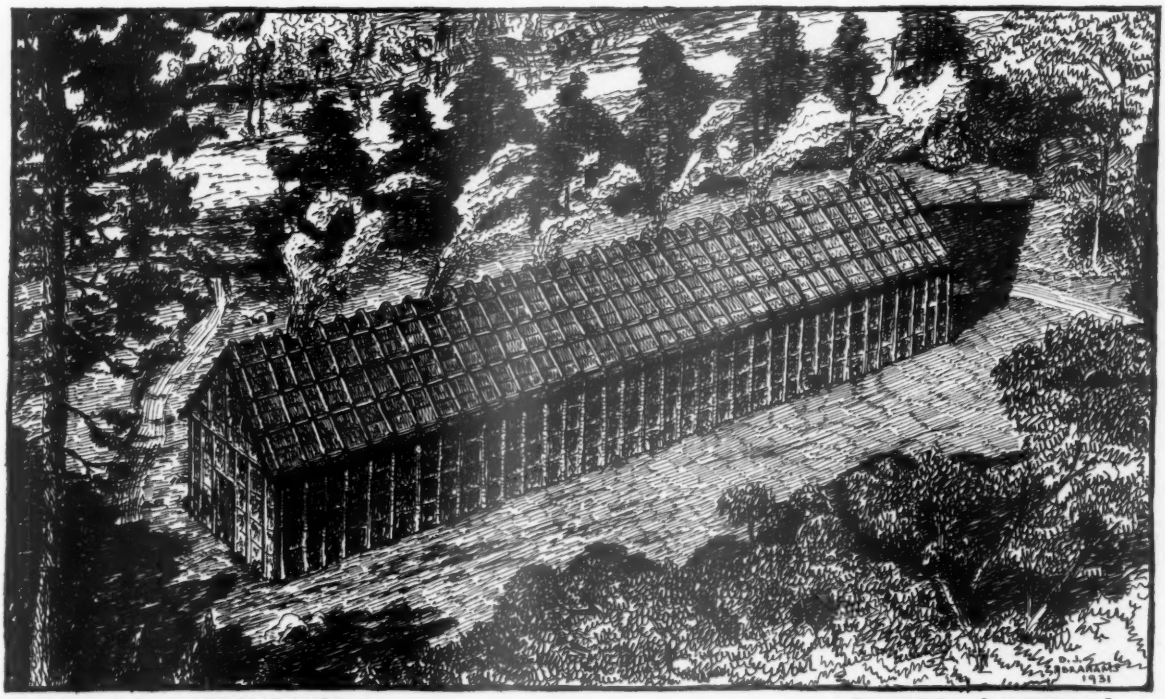
ADVANCES in theory and extensive research work have aided materially the construction of large bridges, in fact, refinements in theory and experiments are called for and justified mainly in connection with structures of unusual size. The refinements in theory include the elaborate calculation of secondary stresses of all kinds, stresses which are usually neglected in ordinary structures, but whose magnitude it is well to determine, and where necessary provide for, in larger ones. Such elaborate calculations were carried out in connection with the Hell Gate Bridge, the Hudson River Bridge and more extensively in the Kill van Kull arch.

Stress determinations by calculation are now being supplemented by stress measurements on models. In order to check the highly statically indeterminate stresses in the towers of the Hudson River Bridge a celluloid model six feet high of one of the tower bents was constructed and the stresses were measured by means of very sensitive extensometers. For the Kill van Kull Bridge a complete model of the main arch was built of brass, loaded in various manners vertically as well as horizontally and the stresses measured by extensometer. A complete model of the Mount Hope Suspension Bridge was recently built by Professor Beggs of Princeton and the stresses in it measured with excellent results.

As a further means to check the theory, stress

(*Concluded on page 464*)

BUILDING THE CONCRETE ARCHES OF THE WESTINGHOUSE MEMORIAL BRIDGE, PITTSBURGH



IROQUOIS LONGHOUSE : : NORTH AMERICA :

NEEDED: A HISTORY OF BUILDING CONSTRUCTION

At Last a Builder Speaks for His Profession

By Thomas F. McSweeney

Illustrated by David J. Abrahams

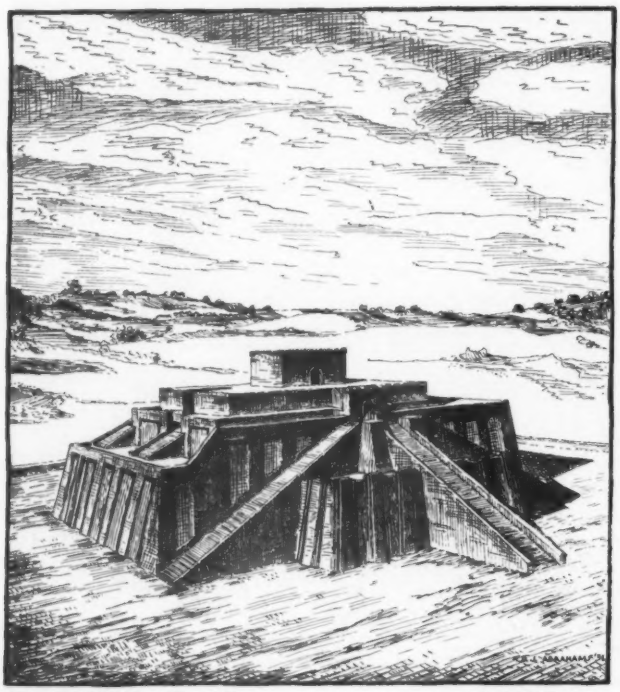
See page 434

OF ALL the work done by our ancestors, there is nothing which tells more of their character, their culture, or their development than the remains of the activities of their building constructors. As soon as man discovered the advantages of village life and began to build a permanent home for himself, the builder became an essential figure in society, and his importance has grown with the increasing complexity of the lives of the people he has served. In the very name by which they called themselves, the Iroquois Indians have left us a clear indication of the status of the builder in the early stages of culture. To the Iroquois, his race was the "People of the Long House," and a study of the Long House tells almost the entire story of the people who lived in it.

And so it has been throughout the history of our own race. The pyramids of the Aztec, the Mayar and the Inca, of the Egyptian and the Chaldean, express in building stone the loftiest aspirations and the keenest ambitions of those people as interpreted by their masons. To the builder, Greece is best illustrated by its temple construction, Rome by its concrete and its arches, and medieval Europe by its Gothic cathedrals.

It is unfortunate that the builder has remained inarticulate, and has refrained from perpetuating his emotions and ideals in print. Others, whose work is important chiefly because of their influence on the builder, have filled libraries with their comments and observations on construction, but the man who has been actually doing the work has been too busy, or has lacked the inclination, to record his activities. As a result, the builder of today does not profit, either in precept or inspiration, by the achievements of his predecessors. The little information he has is usually doled out to him by a group of writers whose real object seems to be to claim for their own profession any glory arising from the construction of the past, and to assign any blame to the nameless and unhonored builder.

Occasionally, some writer has come forward to assert the importance of the builder, to claim for him his place as the heir of a line of workers as interesting and essential as any other, and to proclaim that the work of the building constructor has always been the expression of the highest abilities of a people, a work truly indicative of their culture and their development. Ruskin



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preached this gospel to the Nineteenth Century, August Choisy has left us his wonderful studies of the construction of the past, and Englebach is today showing Egyptologists that the best method of understanding the early Egyptians is through the study of their quarry methods and the works of their masons. But one was an abstract thinker, one an engineer, and the third an archæologist, and none of them a builder speaking for his profession. When the builder does tell his story, as John Smeaton did 200 years ago, or as Colonel Starrett has recently, the light they shed emphasizes the general darkness covering the subject.

IT WOULD seem, then, that we need a History of Construction. Its preparation would be a fascinating task, presenting unexpected difficulties, yet opening up equally unexpected vistas of information. Research into this field should include two main sources of facts: texts of general history, and the specific histories of the arts and professions. Each has its advantages; each has its weaknesses. The general history usually deals with the political phases of man's growth, marshalling long lists of dates and dynasties which soon, by their very dullness, dry up any desire to read further. But it gives the necessary background for the study of construction, and points out the relationship between the works of the builder and the other activities of his time. The histories of the arts and professions are valuable in that they give more specific information than political history, but their specialization is apt to create a biased viewpoint; and until recently they have been mostly esoteric works, too technical and profound for the layman and useful chiefly as textbooks and works of reference.

If the proposed History of Construction is to make its greatest appeal, it should be prepared for those who like to read history, but who have neither the time nor the inclination to ferret it out from the type of books just mentioned. The best medium of presentation would probably be the new method of "story" telling, initiated by Mr. Wells in the "Outline of History." Since the "Outline" there has been a long list of "stories" of this and that, with each writer showing how the race has developed by examining the growth of the interest he himself holds paramount. Thus we have the Story of Philosophy, of Science, of the Bible, of Architecture, of Music, and of many more. Into this group fall such books as Paul de Kruif's "Microbe Hunters," which gives a series of biographies of great bacteriologists; James A. Tobey's "Riders of the Plagues," which describes man's advance in the light of his achievements in sanitation; Magoffin and Davis' "Magic Spades" (the authors call it the "Romance of Archæology"); and many others whose real identity as a "story" book is hidden behind an alluring title. If accurate, these books are very well worth while. Everybody has his individual interest, and the deeper he burrows into it, the less his chance of understanding the many other phases of the work of his fellows. If the volume is readable, and short enough for the time most of us can afford to devote to bacteriology or archaeology, it opens up a new field formerly closed.

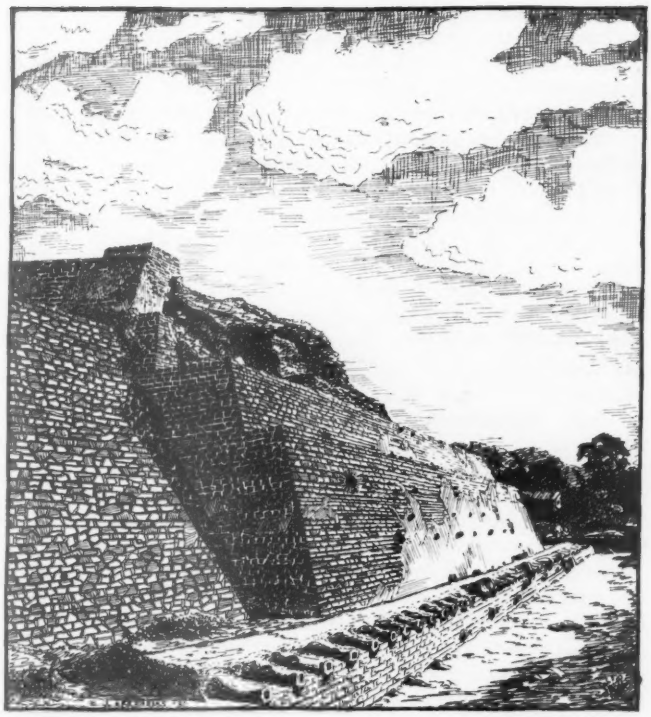
INCA ARCHITECTURE AT MACHU PICCHU : : PERU :

There is one point on which all the "story" tellers agree: they are unanimous in the thought that to understand mankind, one must have a thorough understanding of their particular subject. "Art," says C. Howard Walker, "is the measure of civilization." Fleming and Brocklehurst disagree with Mr. Walker, claiming that "the history of engineering is the history of civilization." Dr. Howard W. Haggard in "Devils, Drugs, and Doctors" looks at the matter in still another light. He says that "the position of Woman in any civilization is an index of the advance of that civilization; the position of Woman is gauged best by the care given to her at the birth of her child. Accordingly, the advances and regressions of civilization are nowhere seen more clearly than in the story of childbirth." And who is there to dispute any of these writers? To the artist, the state of a nation's art is the surest index of its development; the mechanical engineer looks to the condition of its turret lathes; the doctor to its obstetrics; and each finds the answer he is seeking.

But with this acceptance of a common starting point, all agreement between the "story" tellers ends. They are specialists, frankly looking at things in one light, and as frankly disagreeing with each other on most of the things they examine. Man has not developed evenly along his entire intellectual front, and at any given period may have carried one phase of his growth forward while allowing some other to lag behind. If one of these writers attempts a dissection of the men of a time during which his own subject is flowering, the period is one of progress and power; but if the age is one when his hobby is being neglected, the picture becomes dark indeed.

Take, for example, those centuries called (by some) the Dark Ages. Dr. Will Durant, in the "Story of Philosophy," skips from Aristotle to Sir Francis Bacon, indicating what he thinks of the mental attainments of the men of the intervening years. Dr. Thompson, in the "Story of Science," sees an utter lack of scientific progress in medieval Europe and agrees with Dr. Durant. But Dr. James J. Walsh, who is surely entitled to as much credence as anybody on the subject, shows the other side of the story in the very title of his book, "The Thirteenth, the Greatest of Centuries." Ralph Adams Cram and Russell Sturgis, historians of architecture, look at the waxing of Gothic architecture in the Thirteenth Century and feel that there is much to say in favor of Dr. Walsh's contention. And now comes Dr. Tobey, who investigates this same century and finds it absolutely Stygian, as indeed any public health officer must, when he remembers the terrible epidemics which raged even as the wonderful towers of the great cathedrals were being raised to the greater glory of God.

And so the Thirteenth Century was dark or luminous depending upon the viewpoint of the observer. Where the balance should swing, weighing the blossoming of the Gothic cathedral, the work of St. Louis the Monarch, St. Francis the scholar, and Dante the poet against the stagnation of philosophic and scientific thought and the absence of sewers, is far beyond the judicial powers of a builder to decide. Let each judge (*Continued on page 464*)



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THE BOILER OF THE LONDON AND NORTHEASTERN HIGH PRESSURE STEAM PRESSURE OF 450

STEAM'S FUTURE

The Locomotive Today Stands Ready to

By Harold

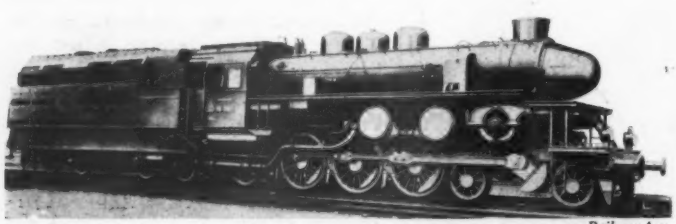
See

IN A previous article, published in The Review for last May, the history of steam's prestige as the dominant form of railroad motive power was traced. At its conclusion the article referred to the lengthening of engine runs within the past few years as illustrative of steam's destined supremacy in the years to come from the application of what, so far as engineering skill is concerned, has been at hand a long while.

On the Union Pacific, for instance, through passenger trains now travel from 500 miles to nearly 900 without engine change, while formerly the distance was but 100 to 175 miles. Runs in freight service on this road now range from 162 to 325 miles as compared with previous shifts every 75 to 150 miles. The Santa Fe and the Southern Pacific are now running passenger locomotives without change from El Paso to Los Angeles, 815 and 888 miles, respectively; the Illinois Central from New Orleans to Chicago, 922 miles; the Northern Pacific from Jamestown, N. D., to Missoula, Mont., 904 miles. At present, passenger service on this last-named road between St. Paul and Seattle (1,904 miles) is accomplished with but two locomotive changes, whereas five years ago 13 runs were in effect between these terminals. Also some through locomotive runs have been established over more than one road: in passenger service between Boston and Montreal through coöperation of the Boston and Maine with the Canadian Pacific and with the Central Vermont and the Canadian National; for coal traffic by the Reading and Western Maryland; in both freight and passenger service by the Reading and the Pennsylvania and by the New Haven and the Boston and Maine.

It is not difficult to understand how extending the runs operates to reduce the needed number of active locomotives required to cover a prescribed territory; to cut down the number of layover terminals; and to strike a body blow at the pertinacious doctrine of the "assigned" engine, a philosophy endemic in the old-time operators. The time is past when a locomotive can be run only by a certain engineer and fireman and must be bunked in a roundhouse when its particular crew is off duty.

Nor does it require extraordinary sagacity to visualize the import of a feat like the following: Last August the St. Louis-San Francisco took a newly delivered Mikado from Baldwin and successfully ran it 9,743 miles in the 31 days of that month in freight service between Kansas City and Birmingham, handling an average of 2,661 tons. The engine was operated by 80 crews and under steam continuously 740 hours (but four hours less than the whole month of August) without having its fire drawn.

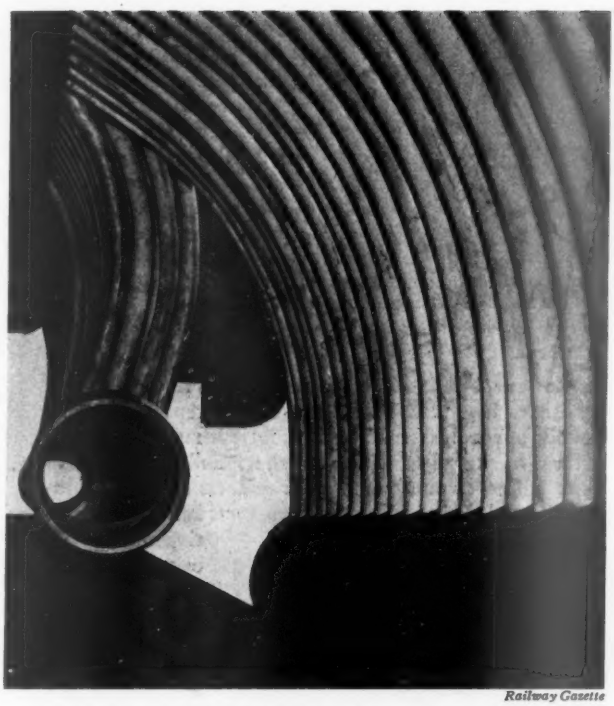


Railway Age

KRUPP-ZOELLY TURBINE LOCOMOTIVE ON THE GERMAN STATE RAILWAYS. IN PRACTICE IT HAS SHOWN ECONOMIES IN FUEL AND WATER

The benefits derived from improvements in the combustion of fuel by an enlarged grate area and other means, from the cast steel locomotive bed with integral cylinders eliminating many heavily strained bolted joints, from larger tenders, from more careful attention to lubrication and to water supply, have all played leading parts in dispelling early forebodings as to the wisdom or practicability of the lengthened runs. There is good reason to suppose that the time will come when runs of 2,000 miles will be accepted, up-to-date American practice.

Concerning lubrication, there is no question that it is an extremely important consideration in the successful running through of locomotives, and a more general adoption of forced feed for cylinders and Alemite fittings for boxes and other parts is to be expected. But it is not true, as is sometimes asserted, that a revolution in lubricating methods has made the longer runs possible. Instead, the provisions for adequate engine lubrication were available for many years, although not always used until the desire for stretching out the runs made their adoption imperative.



Railway Gazette

WATER-TUBE 4-CYLINDER COMPOUND LOCOMOTIVE. IT DEVELOPS A
LBS. PER SQUARE INCH

ON THE RAILROAD

Fulfill the Motive Problems of Tomorrow

E. LOBDELL

page 436

Feedwater, its quality and preparation, though less frequently mentioned, is a feature probably as responsible as any single factor. In years past it was not unusual for connecting divisions of a railroad to have such different qualities of water as to make it practically impossible to operate locomotives over both. If fed with the softer waters of one division, a locomotive, previously scaled with the hard waters of another, often had this scale loosened with resultant leakage, poor steam, and engine failures.

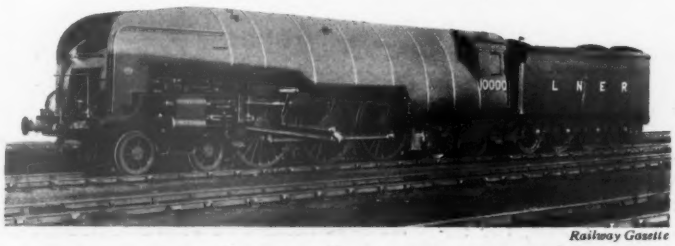
Some of the worst natural water in the United States for steam locomotives lies along the route of the Northern Pacific, especially in the territory of its 904-mile run. To overcome this condition water softening plants, employing the lime soda ash process and the zeolite, have been installed. Through this treatment there is obtained an appreciable amount of sodium and potassium carbonates which are commonly associated with foaming troubles, so enginemen are required to blow down their concentrates periodically and to use castor oil emulsion to allay foaming. Thus the Northern Pacific's water problem seems to be working out satisfactorily and, on the basis of further experience, more progress is to be anticipated.

In all steam locomotive services this matter of getting clear, soft, uniform water is a prime topic. Its bearing on the life of flues and fireboxes can be seen in the maintenance records of the Chicago and Northwestern, which road has been engaged in an intensive study of the feedwater problem for upwards of ten years. In 1911 it had 787 failures from leaky flues, or one per 58,633 locomotive-miles; in 1929, it had only 11 such failures, or one per 4,343,302 locomotive-miles.

For some time the efficacy of roller bearings on leading truck axles has been admitted and, beginning in the spring of last year, their applicability for use in driving boxes has been rigidly tested in a 4-8-4 engine built by the American Locomotive Company for the Timken Roller Bearing Company. On it roller bearings were applied to trucks, drivers, trailer, tender, booster, headlight generator, valve pilot and flue blower. The specifications were a compromise between the current prevailing design practices for freight and passenger services in order that the demonstration engine might be loaned to several roads for test operation under numerous service conditions.

On the basis of its first six months of experience, during which it hauled all sorts of trains upwards of 50,000 miles on the Pennsylvania, New York Central, and Chesapeake & Ohio, it is claimed that roller bearings can stand up and give service free from maintenance troubles, while their extra cost is not prohibitive. The results with this engine seem to prove that the roller bearings, operating in a bath of oil, do not require attention more often than quarterly or semi-annually, which bears out the experience with some 160 other locomotives on which some wheels have been equipped with roller bearings.

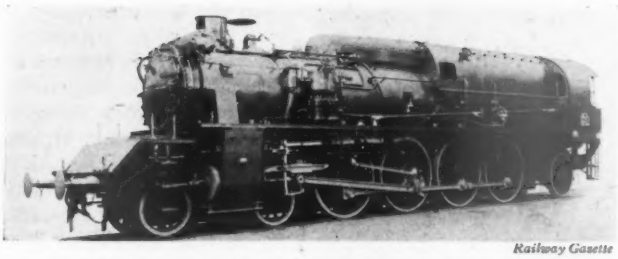
The possibility that this Timken locomotive may indicate the way to a combination engine for freight and passenger service, except for heavy drag coal and ore service, is of tremendous significance to the carriers. Such an interchangeable motive power unit possesses intriguing possibilities for reducing capital investment and its suggestion comes at a most propitious time. Up to the War the railroad people had been accustomed to buy in a manner, which, in retrospect, seems reckless, but their major problem, as they saw it, was to finance the expansion which they deemed necessary. They proceeded, actuated by the well-founded hunch that the country would grow up to almost any additional facilities



Railway Gazette

EXTERIOR VIEW OF THE "HUSH-HUSH" LOCOMOTIVE, THE BOILER OF WHICH IS SHOWN ABOVE. NOTE THE NOVEL CONSTRUCTION DESIGNED TO DEFLECT THE SMOKE UPWARD AND TO CUT DOWN WIND RESISTANCE

and, between 1890 and 1920, freight traffic increased 60% to 80% each decade, while passenger business, in terms of passenger-miles traveled, increased even more than the freight, doubling itself between 1900 and 1910.



Railway Gazette

ULTRA-HIGH-PRESSURE 4–8–2 EXPRESS LOCOMOTIVE BUILT BY HENSCHEL & SOHN IN COLLABORATION WITH THE GERMAN SCHMIDT SUPERHEATER COMPANY FOR THE PARIS-LYON-MÉDITERRANÉE

During the ten years following the War the marked influence of motor trucking, waterways and pipe lines on freight movement and of private automobiles, busses, and airplane services on passenger business have been so thoroughly elaborated in the public prints as to need no further emphasis here. So, faced with a growth in freight traffic since 1920 of less than 10% and with a decline of a third in passenger business (approximately $400,000,000 per annum), it is apparent why the railroads are now attentive to any reasonable proposition whereby pooling of motive power for use in either service may be brought about.

Railway Age

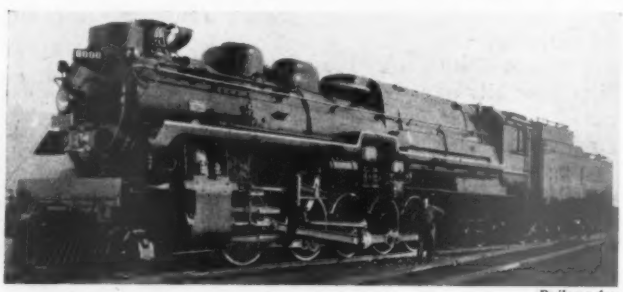
THE "JAMES ARCHBALD," THIRD OF THE SERIES OF HIGH-PRESSURE LOCOMOTIVES WITH WATER TUBE FIREBOXES, DESIGNED BY J. E. MUHLFELD AND BUILT BY THE AMERICAN LOCOMOTIVE COMPANY FOR THE DELAWARE AND HUDSON. LIKE ITS PREDECESSORS, THE CYLINDER ARRANGEMENT IS CROSS-COMPOUND. TOTAL WEIGHT: 356,000 LBS. OF WHICH 300,000 IS CARRIED ON THE DRIVERS. MAXIMUM TRACTIVE FORCE: SIMPLE, 84,300 LBS.; COMPOUND, 70,300 LBS. TENDER EQUIPPED WITH BETHLEHEM AUXILIARY LOCOMOTIVE, OR BOOSTER, WHICH REPLACES REAR TENDER TRUCKS AND EXERTS A TRACTIVE FORCE OF 18,000 LBS.

Any further and complete enumeration of the developments in locomotive design, which have passed the experimental stage and have met the test of service conditions, is beyond the scope of this article. But two points may here be mentioned as illustrations: the increased carrying capacity of tenders which, besides saving time by eliminating long stops for rewatering and refueling, has thereby lessened the chances for break-in-two's when stopping and starting heavy freights; and the air compressing plant which has undergone several steps for improved efficiency of output as well as capacity to care for the ever-increasing use of air for auxiliaries such as brakes, sanders, bell ringing, fire-door engines, reversing gear, ash-pan engines, grate shaker, and water scoop.

Although compared with the progress in other branches of steam engineering, the steam locomotive may have appeared backward in adopting many devices which have long been standard practice in industrial plants, the answer is, of course, to be found in its inhibiting physical limitations. Contrasted with an industrial plant of 4,000 horsepower, the locomotive in American practice must confine itself to a width of 10½ feet, and in height must conform to a clearance requirement of 22 feet, or, in some states, of 18 feet. In practice, 16 feet is the maximum height to which a locomotive may be built for western roads in the United States and 15 feet for eastern roads. Its length and weight must be kept within the bounds of roadbed, rails, and bridges; it must be mobile; it must be rugged to withstand shock and vibration. An extra boiler, or pumps and other gadgets common to industrial and marine plants, are ruled out and the locomotive must lug its own coal pile.

Nevertheless, some progress has been made to try out the water-tube firebox and to apply the turbine. Both are to be counted among the cards which steam has up its sleeve to reaffirm its prestige in the years to come when, on the basis of fuel economy, detrimentally higher first costs, and complications of design may be offset.

Boiler pressures, which were generally limited to 150–160 pounds up to the time when steam was ousted from the Baltimore tunnels in 1895, advanced soon thereafter to 200 pounds for a prevailing practice and then rose gradually to 250–275 pounds as shown by the table on page 381 in the May Review. Today pressures on locomotives of the conventional type, with barrel boiler and stay-bolted firebox, do not commonly range above 275 pounds although the Delaware and Hudson Company has built an engine with a maximum of 325 pounds, for which the American Locomotive Company constructed the boiler. Baldwin has also delivered one to the Santa Fe with 300 pounds as its limit.

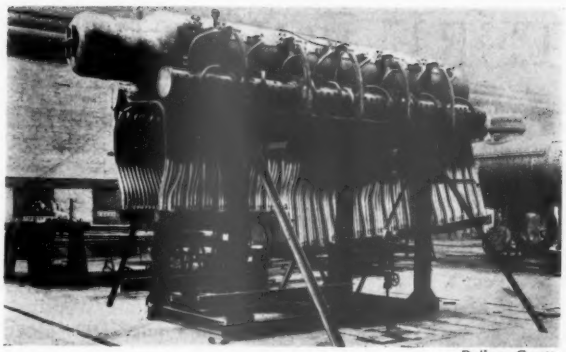


Railway Age

CANADIAN PACIFIC DOUBLE PRESSURE 3-CYLINDER OIL BURNING LOCOMOTIVE EMPLOYING THE SCHMIDT METHOD OF INDIRECT STEAM GENERATION. IT HAS A TRACTIVE FORCE OF 90,000 LBS.

Immediate further increase of working pressures in this type of engine is unlikely, for the Interstate Commerce Commission does not permit stay-bolt stresses greater than 7,500 pounds to the square

inch, which ruling precludes taking benefits from the use of improved materials. Though the carriers are agitating for a higher stress allowance, which could be satisfactorily withstood by alloy steels, the Commission so far has stood pat on the "safety-first" argument that in repair work done by the railroads it is likely regular material would be used in replacing broken bolts.



Railway Gazette

ULTRA-HIGH-PRESSURE BOILER OF THE COMPOUND EXPRESS LOCOMOTIVE BUILT BY HENSCHEL & SOHN FOR THE P-L-M SEE PAGE 473

American experience with water-tube firebox has so far been limited to about four experimental locomotives: Baldwin's No. 60,000 of 1926, using 350 pounds pressure, water-tube firebox, fire-tube boiler and three cylinders compounded; the three of the Delaware and Hudson's series built in 1924, 1927, and 1929, by the American Locomotive Company, using pressures of 350, 400, and 500 pounds, and named, respectively, *Horatio Allen*, in honor of the operator of the *Stourbridge Lion; John B. Jervis*, after the chief engineer of the Delaware and Hudson Canal Company; and *James Archbald*, after an early associate of Jervis. Their fireboxes have all been part of a single-pressure generating system; that is to say, the entire steam generator has carried but one steam pressure. Some details of the *James Archbald* accompany the illustration on page 450.

All these locomotives have shown a high thermal efficiency and have made excellent records in fuel economy, as would be expected. Of course, compound cylinders and water-tube fireboxes, which emphasize the problem of the fatigue of metals in the firebox due to the expansion and contraction caused by temperature and vibration, increase the tendency toward more failures and higher maintenance. Just how soon the use of special steels and revised design practice may be expected to lick these impedients is an open question.

Abroad, the higher cost of fuel and lower cost of labor, as compared with conditions here, have coped more easily with inertia against giving the new type a trial. There the Schmidt principle, using two pressures, has been tested with success by the *Deutsches Reichsbahn* and also in an experimental locomotive (*Continued on page 473*)

M. I. T. Photo

COMPLETE MINIATURE RAILROAD SYSTEM BUILT BY STUDENTS OF THE COURSE IN RAILROAD OPERATION AT TECHNOLOGY. THE SYSTEM INCLUDES APPROXIMATELY 200 FEET OF 2½ INCH GAUGE TRACKAGE. MORE THAN 2,000 FEET OF WIRE WAS NECESSARY FOR THE VARIOUS SIGNALS CONTROLLING THE MOVEMENT OF THE TRAINS. BLOCK SIGNALS, AUTOMATIC TRAIN CONTROL DEVICES, HIGHWAY CROSSING DANGER SIGNALS, AND OTHER MODERN RAILROAD DEVICES OPERATED PERFECTLY WHEN THE SYSTEM WAS DISPLAYED AT THE ANNUAL OPEN HOUSE OF THE INSTITUTE ON MAY 2.

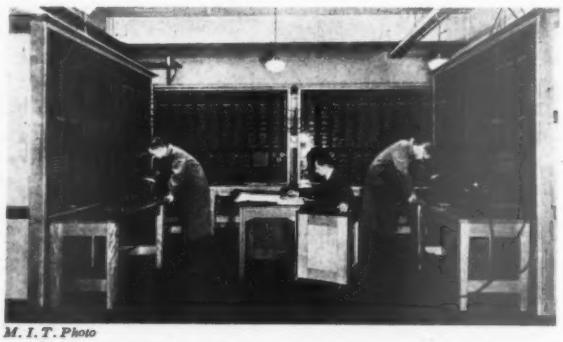
MINIATURE POWER SYSTEMS

How Vast Electrical Transmission Networks Are Duplicated and Studied in a Laboratory

By Samuel H. Caldwell and Harold L. Hazen

See page 436

MANY times during the past year a power-system engineer has sat down in the Electrical Research Laboratory of the M. I. T. with his system electrically reproduced in miniature before him. He has operated the system with the important meters of widely separated stations brought together on a single table, and has observed the effects of projected changes and additions. This has been accomplished by means of the M. I. T. Network Analyzer, which was introduced for use by power companies in January, 1930. It is a group of resistors, reactors, condensers, and phase-shifting transformers, sufficiently numerous and flexible so that practically any power system can be electrically reproduced in miniature, and thus in effect brought into the laboratory for study and precise measurement.



M. I. T. Photo

GARGANTUAN POWER SYSTEMS ARE REDUCED TO LILLIPUTIAN DIMENSIONS. THE M. I. T. NETWORK ANALYZER WHICH OFFERS, IN A SINGLE ROOM, MEANS FOR MAKING ACCURATE TESTS ON TRANSMISSION LINES AND EXERCISING QUANTITATIVE FORESIGHT IN PLANNING POWER SYSTEM GROWTH AND DETERMINING OPERATING POLICIES. IT IS AVAILABLE TO THE ENGINEER OF ANY COMPANY FOR USE IN SOLVING HIS NETWORK PROBLEMS; DEFINITE PROBLEMS CAN BE HANDLED BY THE STAFF

After this year's experience in coöperation with various system engineers, it is now possible more definitely to state the types of problems on which the Analyzer is useful, and the ways in which it can be made most directly of service.

The engineer whose business it is to design and operate a modern highly organized power system is already aware of the specific electrical problems which he encounters on such a system, and any catalogue of them would be superfluous. Satisfactory means for their solution, however, is often wanting. Neither direct computations nor the direct-current calculating table prove generally useful for problems of normal operation, good as they are for approximate short-circuit studies. Consequently, a discussion of some of these problems, which shows how the Network Analyzer is adapted to answer many of these questions with which the engineer is seriously concerned, may be of interest.

A frequently encountered problem arises due to the normal growth of load on a system, that of determining how the system will behave when additional load is applied. The determination of what portions of the system may become overloaded and the extent to which it will be necessary to relieve such portions is often very difficult. For example, some previously unimportant small tie line in a system may suddenly become a limiting factor and make reinforcement of the line necessary.

With the system set up on the Network Analyzer such a situation admits of direct measurement. Not only is the trouble immediately observed, but without changing the set-up various remedies can be tried to determine the best way of relieving the difficulty. A desirable remedy may take the form of a phase-shifting transformer; on the Analyzer it requires but a few operations to insert the transformer, observe its efficacy, and determine the required rating. The important question of voltage regulation under new conditions can be answered by a set of voltmeter readings taken systematically throughout the network almost as fast as the data can be recorded. Synchronous condensers and tap-changing transformers can be installed in the miniature system, their effects measured, and the required ratings determined.

Also included under the general problem of system growth is the case where new territory is to be covered, involving the construction of new lines, substations, and even generating stations. System extensions are studied on the Analyzer by plugging in additional units to represent them and making instrument readings at significant points in the network. The selection of the design of proposed extensions is facilitated by the measurement of system performance made with the units adjusted to represent each of the various alternatives in turn. All phases of the problem can be examined with the same accuracy as on the actual system but with one very significant difference — on the actual system the physical equipment must be built and installed before any data can be obtained, while on the Network Analyzer the future form of the system can be duplicated just as exactly as its present form, and complete knowledge of its extended characteristics is made available through what amounts to actual operating experience before the construction is undertaken.

The system engineer is often prevented from investigating new ways of operating a system because of the risk of interrupting service. No matter how sure he may be of the advantages to be derived from changes in the method of operation he cannot undertake experiments unless he is sure that continuity of service will be maintained during and after the change. The Network (*Concluded on page 476*)

THE TREND OF AFFAIRS

IN THIS SECTION

Buildings of Glass Bricks (455); Commercial Significance of the New Tungsten Plate (454); Dr. Compton Leads in Reorganizing American Physics (see below); Advertising's Abuse of Science (456); Additional Information On Germany's Pocket Battleship (460); Are There More Than 92 Elements? (457); Finding Uses For New Elements (459); Progress in Aeronautics (459); Can Coal Compete with Niagara? (475)

The A. I. of P.

THERE was recently announced in the press the establishment of the American Institute of Physics for the better organization of physicists in diverse fields, and for the better handling of the problems of publication. Dr. Karl T. Compton, President of M. I. T. and this year a recipient of the Rumford Medal, has been elected Chairman of this Institute, and Professor George B. Pegram, Head of the Department of Physics and former Dean of Engineering of Columbia University, is Secretary. In working out this plan, the Institute will have the benefit of the experience of the Chemical Foundation in matters of scientific publication, as well as the financial assistance of the Foundation in getting the new system of publication under way.

In a memorandum prepared for The Review, Dr. Compton adds significant details to the facts already published. The Institute of Physics is an outgrowth of several years' study of publicational and organizational problems of physicists by two committees of the American Physical Society, one a committee on the financing of publications, under the chairmanship of Dr. Compton, and the other a committee on relationships with the other societies and groups, under the chairmanship of Dr. Paul D. Foote, Director of the Research Laboratories of the Gulf Oil Company.

The organization problems of the physicists are in a certain sense peculiar and different from those, for example, of the chemists. Whereas the men who carry on the important practical applications of chemistry are still called chemists or chemical engineers, the men who are carrying on the practical applications of physics are now largely enrolled in separate, specialized groups of engineers: electrical, mechanical, radio, aeronautical, and so on. Consequently, there is much less solidarity among those who are working in pure and applied physics. In order to bring about closer contacts with all of these groups and to prevent further disintegration into numerous separate groups, as has recently been suggested by men in newly important lines of industrial physics, this new organization has been created.

Ritlase

AT THE PLANT OF THE FORD MOTOR COMPANY IN DETROIT

The American Physical Society, the American Optical Society, the American Acoustical Society, and the American Society of Rheology, have agreed to coöperate in the formation of the A. I. P. Other groups, such as the American Society of Physics Teachers, and various professional societies, have also expressed an interest in joining this organization as soon as its plans are completed. A governing board, consisting of three representatives from each of the affiliated societies, constitutes the group which is at present actively engaged in perfecting the organization. On this board are the Directors of the Research Laboratories of the Bell Telephone Company and the Gulf Oil Company, as well as prominent research men in the laboratories of the

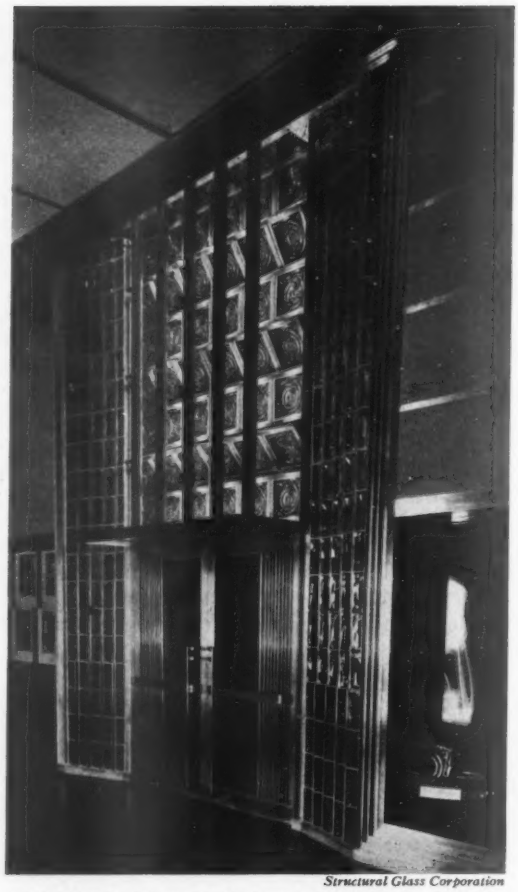
Eastman Kodak Company, the Bell Telephone Company, and various educational institutions. There is also a goodly representation of men who have been prominent as teachers.

The first problem before the governing board of the Institute is the selection of a man to serve as full-time Executive Secretary — a physicist of repute and of proven organizing ability, who will take the initiative in studying and bringing forward plans for reorganizing the management of the physics journals of the country, and who will, furthermore, be active in establishing local physics clubs, student branches, and similar organizations.

One of the interesting possibilities under consideration is the uniting of a half dozen or so of the more important physical journals under a single editor-in-chief, with each journal retaining its present editor and board of editors. All material published by this group would be published as sections of a single large journal, appearing probably bi-monthly. The sections of this enlarged journal would correspond roughly to the present independent journals. Subscribers wishing to obtain only certain portions of the whole journal would receive those sections in which they are particularly interested, which would be published as reprints suitably bound. In this way, every physicist in the country could designate the particular sections which he is interested in obtaining regularly, and receive those sections bound in a single cover twice monthly. This publishing arrangement would give a maximum of coördination and effective service, combined with a desirable flexibility, and would offer unusual advantages in the matter of advertising rates and economical business management.

One of the most difficult problems of scientific publication is the question of scientific abstracts. The plans of the American Institute of Physics contemplate either a more effective relationship with the present physics abstracting journal (*Science Abstract A*, published in London) on a more adequate international coöperative basis, or else a new abstracting journal.

It is hoped that the name of the Executive Secretary of the Institute may be announced before next fall.

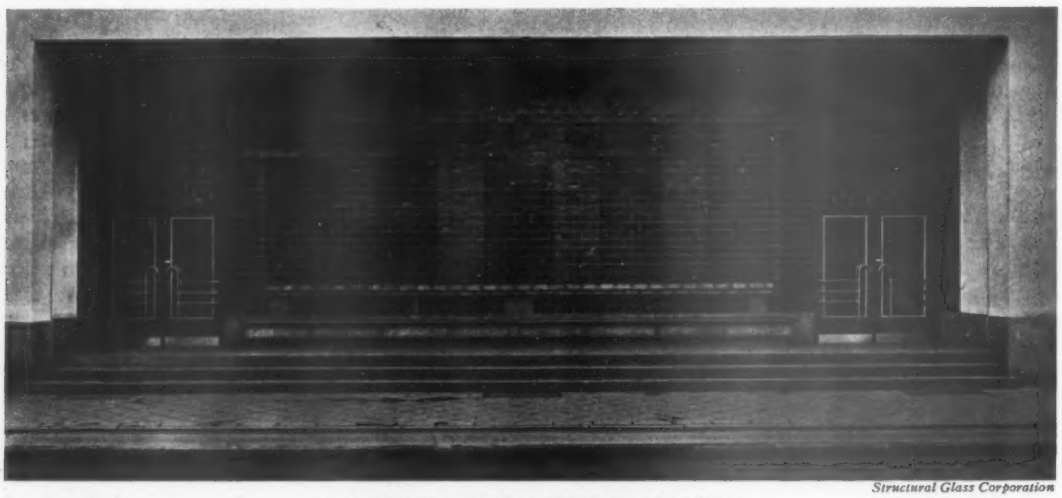


Structural Glass Corporation

GLASS AND METAL BUILDING ENTRANCE LIGHTED BY NEON TUBING. AWARDED GOLD MEDAL AT THE ARCHITECTURAL LEAGUE EXPOSITION IN NEW YORK CITY, APRIL, 1931

Industrial Uses for Tungsten Plate

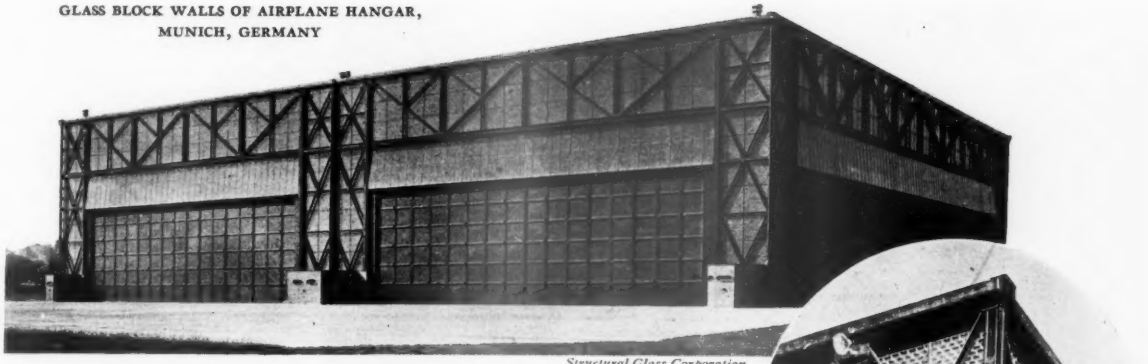
PROFESSOR COLIN G. FINK of Columbia University has announced the discovery of a process by which a great variety of metals may be electroplated with tungsten. The significance and promise of this discovery, one



Structural Glass Corporation

GLASS BRICKS USED FOR SWIMMING POOL FAÇADE

GLASS BLOCK WALLS OF AIRPLANE HANGAR, MUNICH, GERMANY



Structural Glass Corporation

of the most notable since Professor Fink developed chromium plating, becomes apparent when the peculiar properties of tungsten are adumbrated:

1. When electro-deposited, it has a higher lustre than chromium plate.
2. It does not tarnish.
3. It has the highest melting point of all available metals (approximately 3,000° C.).
4. It undergoes no appreciable oxidation at ordinary temperature.
5. It is resistant to the action of acids, neither *aqua regia* nor hydrofluoric attacking it appreciably.

With these properties of tungsten in mind, it is easy to contemplate the manifold uses to which metals with a protective coating of it may be put. Household utensils made of tungsten plate would bring to an end the polishing labors of the housewife. Plated on aluminum, it would furnish an article of lightness and durability.

Its greatest field of utility, however, looms in the chemical industries where resistance to heat and acid is important. A piece of brass which Professor Fink had plated with a tungsten alloy was not noticeably attacked by hydrochloric acid in a week. A coating of any other common metal of equal thickness would have had a life of seconds under similar conditions.

Tungsten's hardness, good heat conductivity, and high melting point make it particularly suitable for electrical contacts and arc points that are subject to extreme temperature changes.

The first attempts to plate tungsten were made by a German chemist, Zettnow, in 1867. He used a bath of molten sodium tungsten, and succeeded in obtaining a tungsten oxide by electrolysis, but he failed to make pure tungsten. The metal was first produced in 1783 by the brothers d'Elhuyar in Spain. Its best known use, of course, is for filaments in electric lamps.

Another recent triumph of the electro-chemist is the electro-deposition of rubber.

Structural Glass Corporation

ENTRANCE HALL OF SOLID GLASS BRICK

Glass Bricks

GLASS has held a place of high importance in architecture for centuries, but not until recently has it been seriously considered as a building material adapted for many types of construction. Structural glass is now being produced in many forms, ranging from tiles of various thicknesses and surfaces, to bricks adapted to comparatively heavy wall and roof construction. Nor does this encroachment in the field of structural materials mean that glass is to lose its position as a means of architectural beauty. On the contrary, structural glass will permit new freedom in architectural design in which the æsthetic sense and practical demands may be completely satisfied in effects conventional or unusual.

German glass manufacturers have led in the development of structural glass units, which are now being produced in various dimensions and in colors to meet the demands of conventional designs. Solid glass bricks ten inches long, five inches wide, and two and a half inches thick are being made. Other forms of various dimensions are hollow bricks reinforced with wire netting, ribbed hollow bricks, and vacuum blocks.

The surface treatment of the German Luxfer tiles and bricks includes prismatic, pebbled, diamond, and modeled faces designed for diffusion and

W. C. West

controlled refraction of exterior light, or for diffused reflection of interior light. This also avoids the black effect in flat glass at night. The glass is said to have great heat resistance. In roof construction these glass units are supplied in precast panels which have a high bearing capacity, and the individual tiles are designed with a special edge groove in which bitumen plaster is laid to seal vertical joints. Studies are being made to find the best type of mortar to use, this being one of the biggest problems yet incompletely solved.

Insulation in wall panels is secured by building panels of bricks formed of two superimposed parts with a sealed air cavity. Such panels have already been used in exterior as well as interior walls. Electrolytically framed tiles set in copper muntins have also been used in walls, ceilings, and even as fire curtains in large buildings. Panels as large as 16 square feet set in metal frames have been successfully built.

Another development in the use of structural glass is the concrete frame window units. These frames are designed for standard dimensions and are machine made. They are adaptable for heavy sheet glass or for glass blocks or tiles. No painting is necessary and they are fireproof, with a much lower heat transmission than steel.

Obviously, the field for structural glass has few restrictions. Germany already has some very striking examples of its adaptability for various architectural designs, including residences, airplane hangars, department stores, offices, and various industrial buildings, such as factories, storage buildings, and power stations.

Investigation of the physical characteristics of glass reveal remarkable qualities. Its composition and surface finish may be designed to meet almost any demand for light control. The thermal conductivity can be varied with structure and density. As for its insulating value, it has remained for European engineers to develop vacuum panes and structural units of vacuum type which are said to have the insulating value of vacuum bottles and to reduce condensation. Walls and windows of structural glass units also eliminate infiltration. Panels built up of glass prism units which are highly fire resistant are now being widely used in Europe.

Glass has remarkable mechanical properties, which depend upon composition and dimensions. It is now possible to produce glass which is harder than quartz. The ordinary tensile strength of the material is approximately 10,000 pounds to the square inch, but it is possible, by special heat treatments, to produce glass of a tensile strength of 50,000 pounds per square inch, or very nearly that of wrought iron. The compression strength of glass exceeds that of granite, concrete, or brick. Architects and building constructors cannot ignore the advantages offered by structural glass. Realizing its great importance, The Review has collected a bibliography which readers may obtain on request to the Editor.

Heaving

IT IS encouraging to note the growing number of dead cats that are being heaved at the scientists of the advertising offices. They are a pawky group, these modernized medicine men, and worship but one god — the great god Sales.

Roberts

But flushed with a dozen successes, they now appear to be over-reaching themselves. The intelligent public, and even a few members of the advertising fraternity itself, are becoming genuinely perturbed over the bad ethics and worse science so common in the advertising pages of the contemporary press.

One of the best aimed volleys at these sales-at-any-price scientists recently came from the editorial offices of *Printer's Ink*, the stodgy but alert little journal of the advertising profession. Suggesting a "Forget Scientists Week," its Editors said: "Perhaps you have been so foolish as to think that scientists work at the business of science. Not so. They test cigarettes, tell frightened mothers about breakfast food, warn young men against the dangers of something that usually ends with -osis. Now and then, to be sure, they make an epoch-making discovery which will bring about an extended revolution in the manufacture of nine-count, full fashioned galoshes. In short, they are scientists of the advertising pages."

John Skara

The Review in the past has had much to say about these gentlemen and it proposes to say much more in the future if present conditions continue. Particularly has it lamented the exploitation of ultraviolet radiation and its by-product, Vitamin D. Ultraviolet light, properly used and understood, may be a great boon to mankind, but it is silly to call it a cure-all, and quackery to over-value products treated by it.

In the deft hands of the advertising scientists, Vitamin D has been made the modern patent medicine. The public has been urged to preserve its health by eating irradiated cereals and bread, to preserve its comfort by having its laundry irradiated, and its underwear soused with Vitamin D. With perfect health and voluptuous comfort thus constantly available, the public has, in addition, been adjured to make itself beautiful by using ultraviolet face cream to create beautiful skin, and by smoking ultraviolet cigarettes to preserve the sensuous loveliness of the Adam's apple. And rumor is at hand that the public will soon be asked to keep itself clean by using ultraviolet soap.

It is indeed time for the advertising gentry to observe a "Forget Scientists Week," and it might well be followed by a "Forget Ultraviolet Lustrum."

Photo by Eugene Hutchinson

Courtesy of the Colorado Fuel and Iron Company

Finger-Prints of the Elements

RECENT newspapers have carried headlines announcing the discovery of the last element, which was found by a new process devised by Dr. Fred Allison, Alabama scientist. The non-chemist will perhaps imagine that the last of Nature's mysteries has been unveiled, at the same time wondering what the new element looks like, what sort of substance it is (gas or glistening metal?), and, after all, how it is known that there are no more elements left to discover? The answers, given with all regard to the truth, will perhaps be disconcerting to him. We do not know what the new element looks like. No one has seen it, or handled it, or possessed it in any palpable form. It is not even certain that it is the last of the elements: we suppose from the evidence that it is probably so, with some hesitation. Nevertheless, if the observations of Dr. Allison are confirmed, chemists will be satisfied that they reveal another element.

Wide World

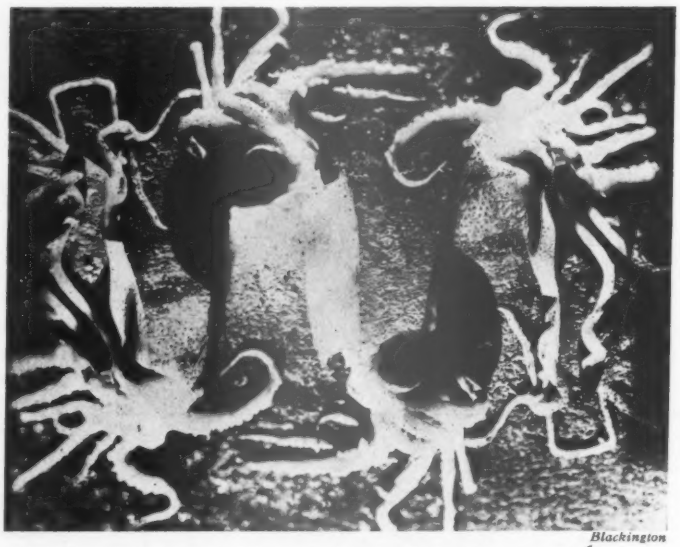
DR. WILLIS R. WHITNEY, '90, DIRECTOR OF THE RESEARCH LABORATORY OF THE GENERAL ELECTRIC COMPANY WITH THE WHITE BOSTON BULL TERRIER RESTORED TO HEALTH FROM AN APPARENTLY INCURABLE FORM OF MANGE BY RADIO HIGH FREQUENCY, OR ARTIFICIAL FEVER, AND OTHER EXPERIMENTS

If all of the known elements, from the lightest, hydrogen (Number 1), to the heaviest, uranium (Number 92), are arranged in the order of increasing atomic weights, and if their x-ray spectra are considered, it appears that the spectra show in general an orderly gradation, a constant difference between adjacent members of the series, except for certain gaps. The gaps have been supposed to correspond to unknown elements, and these, when they have been finally discovered, have been found to show the x-ray spectra corresponding to the gaps in the series. A recent case is that of rhenium (Number 75), discovered by its x-ray spectrum in 1925, and now available in quantity large enough to make possible an inquiry into its fitness for industrial uses. In 1926 the expected spectrum lines of the element illinium (Number 43), were observed by Professor B. S. Hopkins of the University of Illinois. There remained elements Number 87 and Number 85.

Professor Fred Allison of the Alabama Polytechnic Institute has recently developed a magneto-optical method, superior to the analysis of x-ray spectra, which is said to be capable of detecting the presence of an element to the extent of one part among a billion parts of other material. About 15 months ago, Allison and his co-workers reported evidence of the existence of element Number 87, and on May 9, they announced that they had found evidence of the presence of element Number 85 in a number of common substances. If the experiments are confirmed, chemists will be satisfied that all of the gaps in the known series of the elements have now been filled. But this does not necessarily mean that the last element has been discovered. There is no assurance that there may not be an element lighter than hydrogen, although it is simplest to suppose, and seems most probable, that the hydrogen atom contains only one proton and one electron, in which case a lighter atom would be impossible. And there is no assurance that there may not be elements heavier than uranium. The heavy elements are radioactive and undergo a spontaneous breaking down into lighter elements. But uranium, the heaviest of all known elements, is by no means the most radioactive. Sir James Jeans surmises that there may be ultra-uranium atoms so heavy that they have sunk below the surfaces of the stars, leaving no clue in star spectra of their existence. For that matter, unknown elements may be present in the interior of the earth.

More important, perhaps, than Allison's discovery of the new element is his development of the new method which constitutes a more powerful tool for analysis. The method yields only a clue, but a clue by which different substances may be distinguished unequivocally. It will be easier than ever to discover an element before it can be seen.

The history of hydrogen presents an interesting contrast with the present situation. Hydrogen was known and handled long before it was discovered. Paracelsus (1493–1541) observed that when iron was treated with water and sulphuric acid, a gas was disengaged which "rushed off like the wind," and he supposed that the "air" was derived from the water, of which it was an element. Robert Boyle (1626–1691) confounded the gas with ordinary air. John Mayow (1645–1679) collected the gas over water, and questioned whether it was ordinary air. "It is certain," said he, "that it has the same appearance as air, that it contracts by cold, and



Blackington

SQUID BEING PUSHED AS VALUABLE SEAFOOD. THE COMMON SQUID (LOLIGO VULGARIS) HAS A PINKISH OR YELLOWISH WHITE COLOR WITH PURPLISH BROWN SPOTS, AND MEASURES A FOOT AND A HALF IN LENGTH, NOT INCLUDING ARMS. THIS VARIETY IS COMMON IN THE ATLANTIC AND MEDITERRANEAN, SWIMS ACTIVELY IN SHOALS, AND IS SOMETIMES USED AS BAIT

that it has the same elasticity. But for all this, it is hard to believe that it is ordinary air." Nicholas Lemery (1645–1699) observed that if a lighted candle be brought near to the neck of a flask in which iron is effervescing with dilute sulphuric acid, "the vapor will instantly take fire, and at the same time there will be a violent and dazzling fulmination." Some would say that Lemery discovered hydrogen because he distinguished it from air; but others might say that hydrogen was not discovered until about 1783, when Cavendish studied it and showed its relation to the composition of water.

In former times it was necessary not only to catch the criminal but also to confront him with various persons and predicaments to establish his identity. Now it is enough if we have a portion of his finger-print.

Hafnium and Rhenium, or the Metals of the Future

OF THE new elements mentioned above, there are two that are becoming significant because of the possibility of their practical use. The high melting point and the electronic emissivity of hafnium, one of the most abundant of the newly discovered elements, have already led to the taking out of patents for its use in radio tubes and incandescent electric lamp filaments and for the cathode surfaces of x-ray tubes and rectifiers. The metal, of course, is very expensive (about $25 a gram) and its separation is extremely laborious.

Rhenium, a greyish, powder metal, is heavier than gold and has a melting point of 3,440 degrees centigrade, which is higher than that of tungsten. It, too, is very expensive, but when quantity production is achieved, chemists and physicists predict its use in radio and television apparatus.

Certainly these two elements, together with others yet unapplied, should not be ignored in considering new materials for the future.

Aeronautical Briefs

THE aeronautical season of 1931 has progressed far enough so that its general characteristics are beginning to become apparent. If not one of the most prosperous, it is certainly not without some interesting and new features.

Possibly foremost in importance in the commercial market is the light plane movement. Although a much-abused and variously interpreted term, "light plane" is preferable to "power glider" for such small craft as the Curtiss Wright "Junior," the Buhl "Bull Pup," the "Aeronca," and their less well-known competitors. Small planes, with engines of less than 50 horsepower, carrying one or two passengers, are designed to be manufactured cheaply and to be operated by the private owner at a minimum of expense and to sell at retail prices between $1,400 and $1,600. This is possibly the first real attempt that has yet been made to consider the pocketbook of the prospective owner of moderate means.

With the airlines, interest continues to center in the achievements of the Ludington line, operating every hour, on the hour, between New York and Washington. Competing with one of the best train services in the world, at practically equal fare rates, this line has carried from 4,000 to 5,000 passengers a month since its inauguration last September. Operating entirely without government support or contract, it should be earning a small profit on its investment, a very remarkable feat for any independent airline. Many are the innovations adopted by this line to reduce costs of operation. Their flying equipment and engines were secured at a very low figure compared to that paid by other airlines for tri-motored equipment. Its short stages permit the omission of co-pilot and of steward. Its equipment is absolutely uniform, requiring a minimum of diversification of stock and repair equipment. Every refinement of operating practice is used to cut down fuel, inspection, and maintenance cost. Overhead is kept to a minimum; the officers are few; the offices are not elaborate; personnel throughout the line, almost without exception, has had long and real experience on other American airlines. Already lines have been started in the Middle West from Cleveland to Chicago and to St. Louis, emulating the "every hour, on the hour" schedule and similar Ludington practices. Other airlines have increased their service to two-hour intervals. From Germany comes the announcement of an hourly service. It is undoubtedly the most important transport development of the last five years.

The autogiro continues to attract public attention and an increasing number of orders. The Collyer trophy for the year's most distinguished aeronautical development was awarded to Harold Pitcairn, controller of American autogiro patent rights, by President Hoover at a ceremony during which an autogiro had been landed on the White House lawn. Assistant Secretary of the Navy,

Wide World

THE EMISSION SPECTRUM OF RHENIUM WAS PHOTOGRAPHED BY THIS CONCAVE GRATING SPECTROGRAPH. DR. WILLIAM F. MEGGERS IS HOLDING A VIAL CONTAINING HALF A GRAM OF PURE PERRHENATE

Ingalls, flew Secretary Adams to the President's camp on the Rapidan. At least a dozen of the ships are by this time in the hands of organizations which are using them for publicity purposes. The sport model, to sell in the neighborhood of $6,000, has been successfully tested and exhibited at the recent Detroit Air Show. By next fall a determined campaign will be well under way to place the 'giros of this latter type in the hands of the private owner. In the power plant field, research and development are still centered in diesel or modified diesel types. By this time, France, Italy, England, Germany, and the United States have at least one type fully developed for marketing purposes, Germany at least two, and the number under private development is well into the dozens. In this country, the Packard diesel engine has been available for over a year and is in all ways a practical and satisfactory power plant. For some reason, it has not been extensively adopted by the manufacturers or the air lines. Ford and Stinson have both offered transport planes powered by it, a twin engine amphibian has been built around it, and the Northwest Airways made some service tests using it. The actual number of such engines in use by customers must be something less than a dozen. Possibly the recent flight by Walter Lees and Frederick Brossy in a Packard powered Bellanca plane may serve to hasten the adoption of the diesel plant in more aircraft. A duration record of 84 hours and 33 minutes without refueling is indeed a triumph of airplane and engine performance.

On May 27 the technical talent of the industry was entertained by the National Advisory Committee for Aeronautics at its research plant at Langley Field, Va. Annually, for the last six years, this conference has been held, during which the N. A. C. A. has demonstrated its research equipment and asked for suggestions for research programs for the coming 12 months. There was much this year in the way of new equipment for the visiting engineers to see. A seaplane towing channel was officially inaugurated. It has the impressive dimensions of 2,040 feet of length, 24 feet of width, and 12 feet of depth. The car, which will impel the hull shapes to be studied, can attain a speed of 60 miles per hour. The new full-sized wind tunnel, the largest in the world by a goodly margin, was also put through its paces. With a chamber 60 by 30 feet, full-scale airplanes up to large sizes can be tested. The air stream, which can attain a velocity of 115 miles an hour, is created by two full-bladed propellers driven by 4,000 horsepower motors. Such is the power load for the task that the local light and power company must be tied in with a transmission network before the tunnel can be operated at full capacity. Just what results can be obtained from research on these two magnificent pieces of equipment can only be determined in the future. They cannot fail to be of unprecedented practicability and importance.

Deutschland

EVEN as the *Bremen* and *Europa*, two years ago, gave first assurance of Germany's post-war maritime revival on the transatlantic lanes, the launching of the 10,000-ton, 26-knot battleship *Deutschland*, or *Ersatz Preussen*, as she had been called, indicates Germany's initial serious bid to reconsideration as a naval power in the 11 years since von Tirpitz's fleet was scuttled at Scapa Flow. The *Deutschland*, variously hailed by the press as the "pocket battleship," "mystery warship," and "most ingenious fighting craft ever launched," is, for her size, the most expensive war vessel yet built. At $20,000,000 her total cost will be $5,000,000 more than the latest 10,000-ton cruiser of the United States Navy and over two-thirds as much as either the *Rodney* or the *Nelson*, the two post-Jutland, 35,000-ton battleships of the Royal Navy. Each of these mounts nine 16-inch guns. In speed and armament the new German battleship will be within the classification of a capital ship as defined by the Washington Treaty, yet her design and construction conform to the stringent handicaps imposed on Germany by the Treaty of Versailles. She is an illustration of "budgeting methods" as applied to naval design. Starting with the allowable tonnage, the construction of a modern warship is largely a question of balancing the weight assigned to five factors: hull, propulsion machinery, armament, armor, and fuel.

In the *Deutschland*, the saving of about 550 tons, or 10%, of hull by welding has permitted that much more weight to be distributed over the remaining components. Furthermore, a saving in weight has been effected by the special design of powerful, internal combustion machinery. Hence, it has been possible to give the *Deutschland* the armament and armor of a capital ship.

For example, her diesels are said to develop 50,000 horsepower and permit a cruising radius of 10,000 miles at 20 knots. Her main engines are reported as weighing but 17½ pounds per horsepower, which contrasts with the figure of 100 pounds and upwards per horsepower for heavy oil engines on the latest passenger ships.

The following figures, given by Professor William Hovgaard in a paper read in 1929 before the British Institution of Naval Architects, illustrate the difference in weight distribution between the *Deutschland* and *H. M. S. Suffolk*, a British cruiser of the *Kent* class completed in 1928. Each has a standard displacement of 10,000 tons without fuel and water. The *Deutschland* has heavier armament and ammunition (six 11-inch guns in two triple turrets, eight 5.9-inch, and six torpedo tubes) than the *Suffolk* (eight 8-inch, four 4-inch, four 3-pounders, four 2-pounders, and eight torpedo tubes). The geared turbines of the *Suffolk* considerably outweigh the propulsion machinery of the *Deutschland*, but are designed to develop 80,000 horsepower and permit a speed of 31.5 knots as contrasted with 26.

	Deutschland		*Suffolk*	
	Tons	%	*Tons*	%
Hull	3,700	27.0	4,400	31.4
Propulsion machinery	1,150	8.4	1,930	13.8
Armament and ammunition	1,700	12.4	1,000	7.1
Armor	2,700	19.7	2,000	14.3
Various auxiliary machinery	480	3.5	400	2.9
Equipment and stores	430	3.1	430	3.1
Fuel	3,500	25.6	3,460	24.7
Reserve feed-water	40	0.3	380	2.7
	13,700	100.0	14,000	100.0

In this attempt to pack the power of a 20,000-ton battleship into half that displacement, the Germans have brought to bear the experience in welding and the use of special steels gained in building (*Continued on page 474*)

Fellowships in Business and Engineering Administration

THE latter part of June witnessed the fruition of a long-considered and carefully planned expansion of the work of the new Department of Business and Engineering Administration of which Professor Erwin H. Schell, '12, is now Head. The Department, with the cooperation of six industrial and business leaders of the country, has embarked on a graduate fellowship plan aimed to qualify technically trained men of exceptional ability for early advancement to high administrative positions.

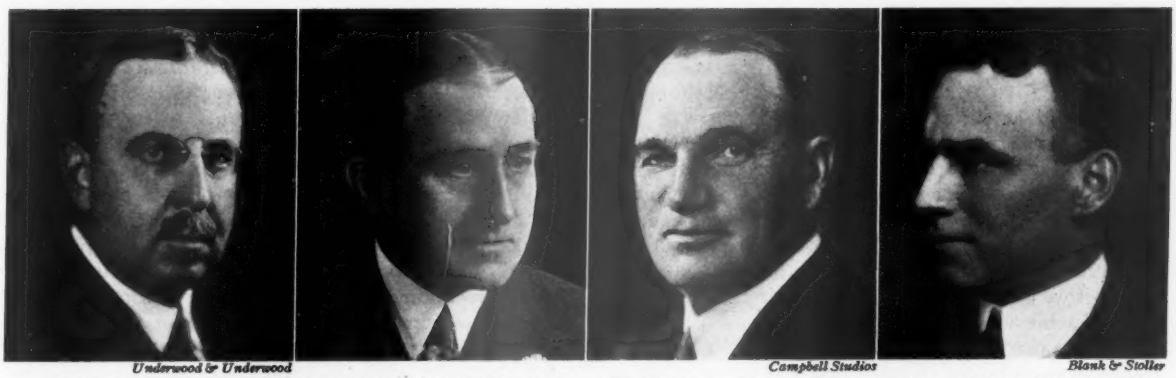
This development, believed to be a pioneer move in business education, is made possible by the establishment in the Department of Business and Engineering Administration of six fellowships carrying stipends of $1,500 each. The business and industrial leaders who have established these fellowships, and who will be the mentors of the six men who hold them, are Lammot du Pont,'01, President of E. I. du Pont de Nemours and Company; Alfred P. Sloan, Jr.,'95, President of General Motors Corporation; John R. Macomber,'97, Chairman of the Board of Harris, Forbes and Company; Francis W. Fabyan,'93, merchant, of Boston; Charles A. Stone,'88, Chairman of the Board of Stone and Webster, Inc.; and Charles Hayden,'90, Senior Partner of Hayden, Stone and Company. Of this group the Messrs. Macomber, Fabyan, Stone, and Hayden are Corporation Life Members; Mr. du Pont a Term Member; Mr. Sloan a former Term Member.

The purpose of the fellowships is to make it possible for a small group of carefully selected young men of proven intellectual ability and outstanding personality to develop their natural qualities of leadership, vision, and sound judgment by special professional training. After they enter the business or industrial field they will make to their sponsors a report of self development each year for five years.

The work to be carried out under the provisions of these fellowships will make it possible for men of exceptional qualifications to avoid many of the obstacles that lie in the usual path of advancement to administrative positions of high responsibility. The holders of the fellowships will live together under the supervision of a member of the Faculty. They will be in constant contact with leaders in various business and industrial fields, and will conduct special researches into current problems faced by coöperating administrators.

The fellowships provide for a summer session and a subsequent year of graduate work in a selected field of concentration in business administration, and they will lead to the degree of Master of Science in Business Administration. The work will include requirements assuring familiarity with the important functions of business; namely, production, marketing, banking and finance, accounting, statistics, business law, personnel administration, and administration policy.

The six men who have been appointed to the first fellowships were chosen after a careful analysis of the records of the 3,500 graduates of the Institute since 1925. The Lammot du Pont Fellowship was awarded to Amerst E. Huson,'30, of Manchester, N. H., a graduate in mechanical engineering. Henry W. Jones,'26, of Bethayers, Pa., a graduate in chemical engineering and now an engineer with the Atlantic Refining Company of Philadelphia, received the Francis W. Fabyan Fellowship. Horace S. Ford, Jr.,'31, of Brookline, who has been taking the course in building construction, was awarded the Charles Hayden Fellowship. Jesse L. Maury,'25, of Neihart, Mont., a graduate in mining engineering and metallurgy, was given the John R. Macomber Fellowship. John C. Leslie,'28, of Coral Gables, Fla., a graduate in aeronautical engineering, was awarded the Alfred P. Sloan, Jr., Fellowship. Wilfred F. Howard,'30, of Nutley, N. J., who was graduated in the course in civil engineering, received the Charles A. Stone Fellowship.



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THE FOUR MEN ELECTED TO LIFE MEMBERSHIP IN THE CORPORATION THIS SPRING. LEFT TO RIGHT: ALBERT H. WIGGIN, CHAIRMAN OF THE BOARD OF THE CHASE NATIONAL BANK OF NEW YORK; JOHN R. MACOMBER, '97, CHAIRMAN OF THE BOARD OF HARRIS, FORBES AND COMPANY; JOHN J. PELLEY, PRESIDENT OF THE NEW YORK, NEW HAVEN AND HARTFORD RAILROAD; AND ALFRED L. LOOMIS, BANKER AND PHYSICIST OF NEW YORK

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BUSINESS AND INDUSTRIAL LEADERS WHO HAVE ESTABLISHED FELLOWSHIPS IN THE DEPARTMENT OF BUSINESS AND ENGINEERING ADMINISTRATION. LEFT TO RIGHT: CHARLES A. STONE, '88, CHAIRMAN OF THE BOARD OF STONE AND WEBSTER, INC.; FRANCIS W. FABYAN, '93, MERCHANT, OF BOSTON; CHARLES HAYDEN, '90, SENIOR PARTNER OF HAYDEN, STONE AND COMPANY; ALFRED P. SLOAN, JR., '95, PRESIDENT OF GENERAL MOTORS CORPORATION; LAMMOT DU PONT, '01, PRESIDENT OF E. I. DU PONT DE NEMOURS AND COMPANY. JOHN R. MACOMBER, '97, CHAIRMAN OF THE BOARD OF HARRIS, FORBES AND COMPANY ALSO ESTABLISHED ONE OF THESE FELLOWSHIPS. HIS PICTURE IS INCLUDED IN THE NEW LIFE MEMBERS OF THE CORPORATION ON THE PRECEDING PAGE

Graduation

COMMENCEMENT exercises at Symphony Hall in Boston on June 9, marked the graduation of Technology's sixty-fourth class. Of the total of 635 degrees awarded, 437 represented the Class of 1931. Included in 171 advanced degrees were nine Masters of Science in Architecture, seven Doctors of Philosophy, and seven Doctors of Science. Four Certificates in Public Health were awarded.

Six women were awarded degrees this year. The degree of Master of Science in Geology was conferred upon Marjorie A. Holden, Hillsboro, N. H., and Louise Jordan of Youngstown, Ohio. Ruth I. Parsons and Emily P. Rickey of Grand Rapids, Mich., were awarded Certificates in Public Health, while Elise du Pont of Wilmington, Del., and Marian C. Andrews of Groton, Mass., were graduated with degrees of Bachelor of Science in Architecture.

Three of the eight degrees of Master of Science in Naval Construction were awarded to officers of the Spanish Navy. They are graduates of the Naval Academy at Ferrol, Spain, who, by arrangement with the United States Navy, were permitted to take the course for naval constructors in the Department of Naval Architecture and Marine Engineering.

The commencement address was given by the Hon. Ray Lyman Wilbur, Secretary of the Interior, and President (on leave) of Stanford University. Employing the slide rule as a symbol, Dr. Wilbur discussed the search for truth and the importance of facts in the upbuilding of civilization. The expert in facts and the man who can arrange them to render a practical service, he declared, is the true guide of the material side of civilization.

This year's graduation was the first at which Dr. Compton had presided as President. He awarded the degrees and introduced the speakers. Dr. Stratton, Chairman of the Corporation, addressed the graduates and extended the good wishes of the Corporation for their success in professional achievement.

As in the past, so again this year the Fifty Year Class, graduates in the Class of 1881, had a place of honor in the academic procession and later were guests of Dr. Stratton at luncheon. The Army and Navy were represented at commencement by Major General Fox Conner, Commanding General of the First Corp Area, and Admiral Louis M. Nulton, Commandant of the First Naval District. Both made brief addresses. Mr. Alexander Macomber was chief marshal of the academic procession, and the Rev. A. L. Kinsolving, Rector of Trinity Church, offered the invocation.

Additions to Faculty

AMONG the notable additions to next year's Faculty are the following:

DR. RALPH D. BENNETT, Associate Professor of Electrical Engineering, graduate of Union College. He received his Ph.D. in physics at the University of Chicago, where he was associated with Dr. Arthur H. Compton in the final experiments which led to Dr. Compton's being awarded the Nobel prize; he held a National Research Fellowship in physics at Princeton and later at the California Institute of Technology, where he developed several interesting electrical devices, including probably the first million-volt x-ray tube. Following this, Dr. Bennett worked at the University of Chicago as a research associate for the Commonwealth Edison Company, and during the past year he has been assisting Dr. Arthur H. Compton in preparing for a series of experiments on cosmic rays. Dr. Bennett has had an unusually wide experience in theoretical and practical electricity, and has a reputation for unusual ingenuity and technique in the line of the work which he will carry on here.

DR. LOUIS B. SLICHTER, Associate Professor in the Department of Geology, graduate of the University of Wisconsin, where he received his Ph.D. in mathematical physics. During the war he carried on important research on the detection of submarines, after which he was employed in the research department of the Submarine Signalling Company. He then formed with Dr. Max Mason, now President of the Rockefeller Foundation, a geophysical prospecting company which has operated successfully for the location of mineral deposits. During the past year he has been engaged in the mathematical study of scientific geophysical problems at the California Institute of Technology. With his mathematical training and combination of theoretical and practical interest in geophysics, Dr. Slichter will bring to his work a valuable fund of knowledge in the important (*Continued on page 476*)

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DURING the past fifty-five years, the constant effort of the Bell System has been to provide efficient telephone service for all the people at the lowest possible price. There are many instances of substantial savings for subscribers.

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Reductions have also been made for lesser distances. As a result of these rate reductions, telephone users are now saving the substantial amount of $20,000,000 annually. You, as a telephone subscriber, are constantly receiving extra value from your telephone—because the number of subscribers is increasing, and the more people you can reach by telephone, the more valuable it is to you.

Today, there are few things purchased by the family or by a business that give so much useful service at such low price as the telephone.

Every time you pick up the telephone you become part of a communication system that uses eighty million miles of wire and represents an investment of more than four thousand million dollars. Yet the cost of local service that puts you in direct personal touch with thousands or hundreds of thousands of people in your town or city is only a few cents a day.

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BROBDINGNAGIAN BRIDGES

(*Concluded from page 444*)

measurements by extensometers on the actual structure have been undertaken. Such measurements are now in progress in certain parts of the Hudson River Bridge and more extensively in the Kill van Kull Bridge.

Finally, in order to gain further knowledge of the actual behavior of large-sized members and connections when loaded to destruction, a series of such strength tests have been undertaken. In connection with the Hudson River and Kill van Kull bridges, for instance, compression tests were made of a number of columns of various materials and of the largest sizes ever tested, taxing the 10-million-pound testing machine of the Bureau of Standards in Washington to its capacity. Many tests of large size riveted connections have also been made in recent years.

Æsthetics

BESIDES the technical advance in bridge construction we may record welcome developments with respect to the æsthetic side. While engineers generally are possessed of a strong sense of utility and are inclined to justify the appearance of any structure from the economic and scientific point of view, there is a marked recognition of the demand of public opinion that proper æsthetic treatment be given to our public structures, and that the collaboration of the architect who is trained and better qualified to develop æsthetic forms and architectural embellishments is essential for that purpose.

In large bridges, of course, the principal lines and proportions of the structure must be determined by the engineer, for they are, to a large extent, dictated by the fundamentals of strength and stability and by local geographical and topographical conditions. Within certain limits, however, the engineer must and can apply his own sense of beauty in determining them. But it is often essential, in order to improve the general appearance of a structure, to mask or supplement certain crude engineering features by architectural embellishments, the design of which must be left to the architect. It is by such collaboration between engineer and architect that some of our modern large bridges have progressed beyond the field of purely utilitarian and scientific structures.

NEEDED: A HISTORY OF BUILDING CONSTRUCTION

(*Continued from page 447*)

for himself; it would take a brave man indeed to attempt to influence the opinion of his neighbor.

It is clear that no just decision on such a point can be made unless evidence has been presented to show a complete picture of the time. As yet we have no facts from the builder. We have, and we should have, the stories of all the other groups, but the constructors, the largest single body in our civilization, have been silent. All the abovementioned learned doctors of one thing and another have been given their days in court; (*Continued on page 466*)

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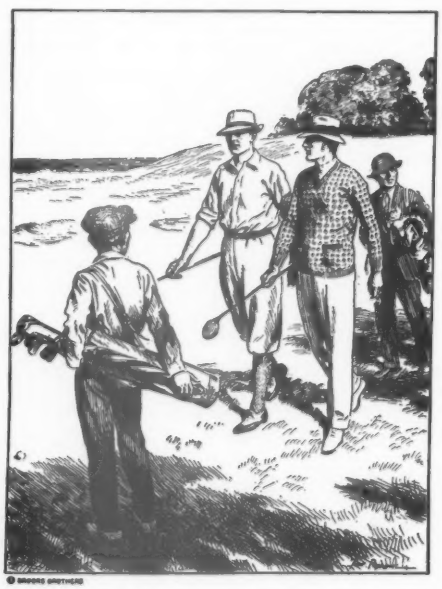

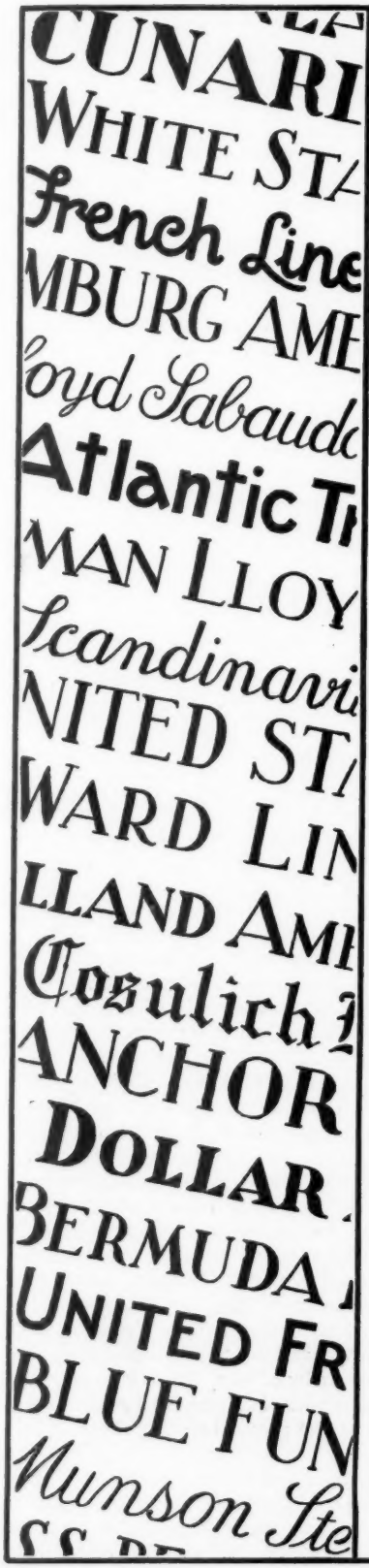

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A complete cruise! It will cover the Mediterranean from end to end — from *Gibraltar* to *Suez* — and call at 22 ports and visit another 22 places on the shore excursions. The rates are $950 and upward, and include return by any Cunard sailing.

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NEEDED: A HISTORY OF BUILDING CONSTRUCTION

(*Continued from page 464*)

they have been allowed to bring forth evidence to show the importance of their contentions and of their subjects. Surely an equal hearing should be granted to a practitioner in the oldest of the mechanic arts.

A HISTORY of Construction, then, should prove a particularly informative addition to the list of stories already told. It is recorded by Professor Shimer in "Evolution and Man" that our ancestors have lived on earth for at least a million years, and that for only 5,000 years have there been any written records to tell us the kind of men they were. For all the rest of this time, if we would redraw the picture of their lives, we must depend on the fragments they left behind them, and of these, the least fragmentary are the remains of their stone construction. Even since man has had a written language to record his doings, we are apt to find the things he did with building stone more accurately informative than the things he said about himself. Remember the fate of Ozymandias of Egypt:

> I met a traveler from an antique land
> Who said: Two vast and trunkless legs of stone
> Stand in the desert. Near them on the sand
> Half sunk a shattered visage lies, whose frown
> And wrinkled lip and sneer of cold command
> Tell that its sculptor well those passions read
> Which yet survive, stamped on those lifeless things
> The hand that mocked them and the heart that fed.
> And on the pedestal these words appear;
> "My name is Ozymandias, King of Kings,
> Gaze on my works, ye mighty, and despair."
> Nothing beside remains. Round the decay
> Of that colossal wreck, boundless and bare,
> The lone and level sands stretch far away.

The glories of Ozymandias are gone. Khufu is but a name, yet the lives of his people are clear and understandable after five centuries because of their activities as builders. The earliest written records of the pyramid builders (carved, by the way, on the stone erected by the masons) tell nothing but what the scribes, or their royal masters, wanted the world to know. Their masonry construction, on the other hand, gives a very full and unstudied picture of the lives of the people who did the building.

In fact, their stonework gives not one picture, but two, and the difference between them is so great that it is amusing. One side of the argument is well stated by the Roman historian Pliny, who looked at the pyramids and saw only a "stupendous memorial to vanity" on the part of the men who ordered them built. On the other hand, such a profound Egyptologist as Arthur Weigall, whose opinion as Inspector General of Antiquities for the Egyptian Government is worthy of every consideration, holds that these tremendous piles of stone were a source of joy and national pride to the people building them. H. G. Wells says the erection of the pyramids "exhausted the resources of Egypt, . . . and left her wasted as if by a war." Again Dr. Weigall disagrees, for he believes that the pyramids were a simple matter for a nation as strong as the Fourth Dynasty Egyptians. (*Continued on page 468*)

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NEEDED: A HISTORY OF BUILDING CONSTRUCTION

(Continued from page 466)

Far from being ruinous, he says the expenditure of labor and treasure was well invested, as the result was so imposing that no enemy would risk assaulting a people capable of such effort.

Give ear to Dr. Weigall. After telling how the great blocks (some of them weighed 50 tons) were dragged up the sides of the unfinished structure on ramps lubricated by water, he says, "Scores of these brick ramps must have zigzagged in gentle gradients up each side of the growing Pyramid; and all day long these gangs of men must have dragged the blocks of stone up them, singing as they went, as Egyptians sing at their work today, while their overseers clapped their hands to lead their songs or swing their whips about in harmless and good-natured energy."

This account doesn't sound much like Pliny. It sounds more like a Boy Scout Song Fest than the forced labor of a nation enslaved to satisfy the all-devouring vanity of a ruler who believed himself semi-divine. It also sounds too much like special pleading to be altogether satisfactory. If Weigall had omitted the "gentle gradients," or the "harmless and good-natured whips," or the singing, his plea would have had more force. No living builder has directed the labor of a hundred thousand Egyptians in the erection of a pyramid, and the building superintendents who had charge of the job for Khufu failed, like their fellows ever since, to record their experiences and emotions, but the building constructor who has put heavy stone into place can assure anybody who has never tried it that the setting of a 50-ton block using nothing but human muscle would be done without music. Like the present-day Egyptian, the southern negro sings at his work, but that work never approaches the magnitude of a pyramid, and when the law allowed the use of whips, the element of good nature was entirely absent.

It is probable that Pliny, a Roman nobleman living at the time of Rome's greatest power and activated by the contempt of his class for anything not Roman, was exhibiting an inferiority complex. Weigall, on the other hand, spent his life investigating the glories of the Pharaohs, and to him, the early Egyptian king could do no wrong. He was sure the pyramid builders were a great, happy people, ruled by wise and benevolent kings, that he felt it necessary to rush to their defense, even against an opponent dead as long as Pliny.

Here, then, are two pictures of the people of the Nile, each drawn from an examination of the work of their masons. They conflict, but either is far clearer than anything we can gather from the written records of the same people. These are confused and broken, and give, at best, nothing but the name of the king and a little of what he thought about himself.

So the story continues throughout the ages. No matter what the race or the time, the things man has built are among the most informative of his activities. Sometimes it is the tools he used in building rather than the building itself, as evidenced by the Mound (*Continued on page 470*)

Unusual air view of the vicinity of The SHELTON, *the Grand Central District, showing Chrysler Bldg. in the foreground.*

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(Continued from page 468)

Builders, of the Ohio. Excavations now being made in the great heaps they left have brought to light obsidian axes and other building tools. Obsidian is a natural glass resulting from an acid lava flow and is not found any nearer Ohio than the Yellowstone. The presence of these building tools, therefore, indicates an extensive commerce on the part of the Mound Builders, and commerce implies so many other things that with this one fact we are well started toward an understanding of these people.

Consider Stonehenge. Knowledge of pre-Roman England is scant enough at best, and most of it comes from what the excavators have found around Stonehenge and similar monuments left by the early British builder. Or consider the Mayas of Yucatan. Archæologists are now attempting to reconstruct the lives of the peoples who lived in Central America 2,000 years ago, a task scientifically impossible without the relics left by the Mayas in building stone. And to realize that this dependence on building construction as a historical index did not disappear in more recent days, remember the boast of the Roman Emperor Augustus, who felt that his greatest achievement was shown in the fact that he found Rome a city of brick and left it a city of marble.

Dr. Walsh and the architects agree that the Gothic cathedrals of medieval Europe are among the chief milestones marking the road over which we have come. Dr. Tobey, even though he can see nothing but darkness in the years others find so brilliant, becomes almost lyric when he tells of the drains of Cnossus in Crete and of the Roman aqueducts of Frontinus. Each of these men, from the Egyptian king of kings and the ruler of the Roman world seeking an index of his glory to the modern scholar looking for the means of guiding his thesis along his own particular route, has chosen the work of the mason constructor as his beacon.

Mr. Cram, in a series of articles on Church Architecture written for the *Churchman*, has lamented the horrible wooden churches which were so common 30 years ago. Comparing them to the stone chapels we might have had, he accused the American people of being "lower than the Maoris of New Zealand or the Pueblo Indians." It is to be hoped that since the country has accepted Mr. Cram's advice and altered its ways he thinks better of us. We have turned over a new leaf in a way which fits very nicely into the present argument. The wonderful renaissance of American culture (beginning about the time of the articles) is shown by nothing else as clearly as in our building construction. Stone chapels in our towns and towering skyscrapers in our cities are surely as expressive as anything could be of the Twentieth Century in America. No one, not even a prejudiced builder, believes that the work of the mason and his collaborators is the whole of this renaissance, but it is an essential part, and one which may be used as an index of all the rest.

There is one point which should be made clear before going further. Readers may ask if this subject is not covered by the extensive series on (*Concluded on page 472*)

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NEEDED: A HISTORY OF BUILDING CONSTRUCTION

(*Concluded from page 470*)

architectural history with which our libraries bulge. The answer is, most emphatically, no. Although most modern architects overlook the fact, it is their chief function to interpret the builder's capacity to assemble the materials furnished by the craftsmen of the building materials manufacturers, the craftsmen whose work stands behind every building ever constructed. The pyramids and obelisks of Egypt were not designed by architects; they developed as the craftsmen of the Pharaohs acquired the ability to handle, quarry, and erect heavy stone.

All architectural histories speak of the Egyptian architect and of his importance in the court of the Pharaoh, but as a matter of fact, the official they extol was not an architect at all, rather the prototype of the modern contractor. Among his other duties he directed the scribes in the preparation of such plans as were used, but the title he bore (and if the records are correct, he bore it proudly) was "Chief Carpenter," or more literally, "Chief of the Men of the Ax." Ancient records list many of these men, but even then they were poor publicists, and we have little information about their lives. For them, fortunately, written records are unnecessary, as their work lives on to tell their successors that they were builders, and not what we know today as architects. This same uncertainty in the minds of writers on architectural history is shown again in their discussions of the building of the medieval cathedrals. They speak of "architects" who were, and who called themselves, master masons. The visitor to Nuremberg is told of the "architect" of St. Lawrence's cathedral who was deposed by his two scheming assistants; how the two new "architects" quarreled while setting the stone trim of a window in one of the two towers and were killed in the resulting fall; how the original "architect" was reinstated; and how his first action was to fill in the fatal window with his own hands. This man may, of course, have been an architect, but he sounds more like a mason. The truth is that on St. Lawrence's and on all the other Gothic cathedrals the form of the building, even to its adornment, was determined by the abilities of the man in charge, the building constructor. The Gothic vault was devised by the builder because of the disastrous experiences his predecessors had had with wooden roof construction, and the beauty of its lines was determined by the construction methods at the command of the master mason. The flying buttress was used not because it was beautiful, but because it was necessary, and its beauty is derived from its utility. The buttresses on Notre Dame are beautiful, but when they are transported to Chicago and pasted on a skyscraper where they are not needed for support, the world finds that their beauty is inherent in use rather than in form.

The difference between the subject matter of a history of architecture and the subject matter of this new book may well be illustrated by the American skyscraper. The tall office building was made possible not on an architect's table, but in the steel mills where men learned how to

make the beams and columns for the skyscraper's skeleton, and in the shops where the inventor devised the elevator that made lofty offices rentable. Present-day magazine articles by architects, discussing the pros and cons of the crowded city, have much to say of Burnham and Root, of Jenney and Sullivan, but nobody mentions Kloman and Kennedy of the steel mills, or Otis and Tufts of the elevators. To the builder, the stories of Piper of the Keystone Bridge Works, of Roebling and his wire rope, and of the unsung heroes who perfected the derrick, are just as important and interesting as the story of "Uncle Dan" Burnham and how he designed the Monadnock Building.

All builders are willing to grant to the philosopher his "Story of Philosophy" and to the physician his "Devils, Drugs and Doctors." The architect and the sanitary engineer may interpret history each in the light of his own art. And now perhaps the builder may understand our predecessors in the light of their efforts in the art of building construction.

STEAM'S FUTURE ON THE RAILROAD

(Continued from page 451)

built by the London, Midland and Scottish. Its latest European development is an ultra-high-pressure compound express locomotive built by Henschel & Sohn of Kassel, in collaboration with the German Schmidt Superheater Company, for the *Paris-Lyon-Méditerranée*. The Schmidt made its cisatlantic début last May in a 2–10–4 engine (pictured on page 450) built at the Angus shops of the Canadian Pacific in coöperation with the American Locomotive Company and the Superheater Company. The first completely American engine using the Schmidt indirect method of steam generation is now building for the New York Central at the Schenectady plant of the American Locomotive Company. It is of the 4–8–4 type.

The Schmidt principle is illustrated by the following description of the *P-L-M* locomotive, taken from the *Railway Gazette* of London. In this engine, steam, rising to 110 atmospheres (1,617 pounds) at high boiler outputs, is first generated in a closed circuit, which (see photograph on page 451) "comprises a water-tube firebox and combustion chamber, the sides and ends of which are formed of tubes expanded at the bottom into the foundation ring and at the top into two horizontal steel drums, mounted centrally above and partly between which is a larger forged nickel-steel drum having an inside diameter of 3 feet, 1½ inches. Tubular heating elements pass into this drum from the closed circuit. Steam is generated from the water in contact with these at 60 atmospheres (882 pounds), this steam being used in the high-pressure cylinders. The exhaust from these is supplemented by steam at 14 atmospheres (206 pounds) generated in the low-pressure boiler, which is of the ordinary fire-tube type with superheater. . . . Only condensate or rain water may be used for make-up purposes in the heating system, since the formation of scale in the tubes must be avoided. . . ."

(Concluded on page 474)

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STEAM'S FUTURE ON THE RAILROAD

(*Concluded from page 473*)

The *Deutches Reichsbahn* have lately been trying out the Schwartzkopff-Löffler which, like the renowned "Hush-Hush," developed by H. N. Gresley, Locomotive Superintendent of the London and Northeastern, uses water tubes not only in the firebox but in the boiler. The Löffler utilizes a working pressure of 1,700 pounds, and the latter 450.

Mr. Gresley's locomotive is not only the longest and heaviest in Great Britain but it departs in appearance from the orthodox steam locomotive as is shown by the photograph on page 449. Like the *James Archbald*, an outside casing insulates and streamlines the upper part and, in the English machine, passageway is provided through the tender to permit a change of driving crew with the train under way.

Turbine locomotive development began in Sweden during the War through the efforts of Frederick Ljungstrom and his brother, Birger, after whose designs an experimental engine was constructed by *Aktiebolaget Ljungstrom Angturbin* at Stockholm in 1921. Since then several larger locomotives of this type, ranging from 1,750 horsepower to upwards of 3,000, have been built and used for regular railway services: in England an express engine for the London, Midland and Scottish; in Sweden a freight engine for the Argentine State Railways and at least two passenger or freight locomotives for the Swedish State Railways.

In the Ljungstrom turbine locomotive the leading section, carrying the boiler plant, is followed by a trailer (of nearly equal wheelbase) bearing the turbine, reduction gearing, and condenser. More of the total weight is distributed over wheels other than drivers, compared with locomotives of the piston type. Besides, according to its proponents, showing marked fuel economy combined with high haulage capacity, the turbine locomotive's camel-like virtue of being suited to long runs without taking water, makes practicable a choice of feedwaters and lessens the needed number of feedwater treating plants.

On the *Deutches Reichsbahn* a differently designed turbine locomotive, first proposed by Dr. Zoelly of Zurich, has in practice shown economies in fuel and water. An experimental engine of this type, furnished for the Seddin Railway Exposition in the fall of 1924, has been for some time used in regular service hauling fast passenger trains between Hanover and Aix-la-Chapelle. In this engine (called the Krupp-Zoelly and pictured on page 448) the turbine is arranged on the locomotive in much the same position as the ordinary locomotive cylinders, with water-cooled condensers closely attached to them.

Though the reciprocating engine will probably remain standard for many, many years, the flat presumption that a high-pressure turbine locomotive will never be developed to give general service as a reliable unit, and one reasonably economical to operate, seems unwarranted. Its large starting torque, absence of dead center and of unbalanced wheel impact loads on bridges and track are excellent recommendations. Extra first cost, maintenance troubles, and complexities of the condensing equipment are holding it back, but recently one or more experimental non-condensing units have been built in Sweden. If these prove out, the future of the turbine locomotive will be correspondingly brightened.

Steam possesses other minor cards to play as the contest for its supremacy in motive power quickens: higher superheat, improvement in the feedwater heating system, smokebox economies, larger exhaust nozzles with corresponding reductions in back pressures, the application of power throttle operating mechanisms, more consideration for the convenience and safety of the engine crew, to catalog but a few trumps. It may be that poppet valves, tried abroad, will displace piston valves; or that unaflow engines, which offer certain advantages in the better utilization of steam as compared with the conventional counter-flow type, will overcome their corresponding disadvantages through experiments now under way.

But the significant trend of railroad motive power requirements in the future is bound to be toward meeting the demands for sustained horsepower capacity at speed. Vast operating economies, present or potential, will get a merited and cordial reception, but only by running longer and heavier full-tonnage trains to their destinations in less and less elapsed times, can the carriers hope to cope with the competition of the automobile and airplane. Steam is readier at present for this coming struggle than ever before and — given 152-pound rails like the Pennsylvania is putting into service, stronger roadbeds, bridges with lighter curvatures than are now the fashion, lower gradients, and with highway crossings eliminated; given better dispatching and signaling, streamlining of trains and, as one authority says, a "pointed stern" to rear-end cars, to cut down suction drawback — the steam locomotive of today will be revealed as a unit already prepared to solve many of the problems of tomorrow.

THE TREND OF AFFAIRS

(*Concluded from page 460*)

the *Koenigsberg*, *Karlsruhe*, and *Koeln*, the three 6,000-ton replacement cruisers so far commissioned. These three, on the authority of Hector C. Bywater, a distinguished British naval writer, have a radius of action of 18,000 miles and their diesels develop one unit of horsepower for every 12 pounds of weight.

It is unwarranted, however, to conclude that the *Deutschland*, and the *Ersatz Lothringen*, a second ship of her class to be laid down soon, presage a revival of the prewar, naval building race between England and Germany. By the Treaty of Versailles, Germany is limited to six battleships of 10,000 tons, standard displacement, six light cruisers of 6,000 tons, 12 destroyers of 800 tons, and 12 torpedo boats of 200 tons. Germany may replace no battleship or cruiser, unless lost, within 20 years from the date of launching, and no destroyer or torpedo boat within 15 years. She is permitted to have no submarines, and her naval personnel is restricted to 15,000 of all ranks. Such a force is indeed puny compared with the 129 submarines turned over to Admiral Tyrwhitt's Harwich flotilla off the Essex coast on November 20, 1918, and the vast armada of the High Sea Fleet surrendered to Admiral Beatty off the Firth of Forth the following day.

Moreover, to call the *Deutschland* "a warship too powerful for ships which can catch her and too fast for ships that can sink her" is an overstatement. There are at present in the British fleet three heavier and faster battle cruisers (*Hood*, *Renown*, and *Repulse*) and five 25-knot battleships of the *Queen Elizabeth* class, all carrying 15-inch guns; the Japanese have three battle cruisers of the *Kongo* class, mounting 14-inch guns and capable of 26 knots; while the London Treaty 10,000-ton cruisers of the United States Navy (such as the *Pensacola*, *Salt Lake City*, and *Northampton*) are capable of 33 knots or better, though mounting lighter armament.

Prime interest in the *Deutschland* derives from the likelihood that its technical lessons may be applied by the various admiralties with resulting basic changes in naval science. To find a possible parallel one must turn back to the conception of the *Dreadnought* as it emerged from Lord (then Sir) John Fisher's committee in 1904. Embodied in this heavily armored, "all big gun" ship was turbine machinery to give a speed of 21 knots. This type of craft with ten 12-inch guns surpassed in offensive power, swiftness, and protection anything then afloat.

Later in the Royal Navy came successively super-*Dreadnought* types, the *Orion*, *King George V*, and *Iron Duke* classes, in which the armament was stepped up to 13.5-inch guns, though the speed still remained at 21 knots. This increased calibre meant a shell of 1,400 pounds instead of 850, and later this weight was to pass 1,900 pounds in the 15-inch ordnance of the *Queen Elizabeth*, *Malaya*, *Barham*, *Valiant*, and *Warspite*, completed in 1915 and 1916. Besides definitely superior armament, the *Queen Elizabeth* class had an increased speed of 25 knots and four of these ships, forming the Fifth Battle Squadron under Admiral H. Evan-Thomas, amply demonstrated in action at Jutland the capability of such a type to withstand heavy bombardment and to retaliate in kind. The *Rodney* and *Nelson* together with the five *Queen Elizabeths* form the battleship backbone of the present Royal Navy.

Steam Competes With Niagara

DRAMATIC testimony to the efficiency of coal-burning electric generating stations is given by the existence of one of the world's largest steam power plants, 22 miles from Niagara Falls. The Niagara-Hudson system put into service last month an additional generating unit at its Huntley steam electric station of Buffalo, raising the capacity of this to 622,000 horsepower, a capacity 50% greater than that of the 448,000 horsepower Schoellkopf hydro-electric station at Niagara Falls.

The new unit added at the Huntley steam station is a 107,000 horsepower generator, the twin of one put into operation earlier this year. Each of these turbine generators requires 418 tons of steam an hour and each is the size of an ordinary dwelling house.

Construction of this huge steam plant on the brink of Niagara calls attention not only to the advances in steam generation, but to the restrictions and political applications which prevent further utilization of the vast power of Niagara. The power expended by the river in its descent of 326 feet from Erie to Ontario amounts to approximately eight million horsepower.

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THE INSTITUTE GAZETTE

(Continued from page 462)

field of physics of the earth, in specialized portions of which investigations are now being carried on at the Institute.

DR. WAYNE B. NOTTINGHAM, Assistant Professor in the Department of Physics, electrical engineer, and Scandanavian-American Fellow at the University of Upsala. After his fellowship he returned to America to join the research staff of the Bell Telephone Company and later was put in charge of certain developments at the Hawthorne Plant of the Western Electric Company. Following this he received his Doctor's Degree on the basis of research on the properties of metallic arcs at Princeton. Since then he has been a research fellow of the Bartol Foundation and has done notable work, first on arcs, and more recently on photo-electric phenomena, electron emission, and properties of metallic surfaces. He has at the same time been a consultant in the design of new apparatus involving amplifiers.

DR. PHILIP M. MORSE, Assistant Professor in the Department of Physics, graduate of the Case School of Applied Science, Ph.D., at Princeton University. While at Princeton he published numerous papers, several of which were in collaboration with President Karl T. Compton, on theoretical interpretation and mathematical formulation of phenomena of discharges through gases. He is the author of several important theories dealing with the spectra, dissociation and energies of chemical molecules and is co-author of the first book in English on wave mechanics. This year he is at the University of Munich as an International Research Fellow.

Sketches of other new professors will appear in the next issue of The Review.

MINIATURE POWER SYSTEMS

(Continued from page 452)

Analyzer is a tool for obtaining this assurance. With it he can try out the new scheme, observe its benefits and deficiencies, correct troubles where they occur, and deliver to his load dispatcher a set of operating instructions complete in every detail. By means of these instructions the change-over can be made with confidence that no trouble will occur and that the desired conditions will be obtained. The engineer, who is considering the advisability of operating his system with generators connected only through feeders to mutual loads (so-called "synchronization at the load") instead of using heavy ties between generators, is confronted with precisely this type

(Concluded on page 478)

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MINIATURE POWER SYSTEMS

(*Concluded from page 476*)

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